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CHEMICAL & ENGINEERING

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Facts & Figures for

Chemical R&D

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CHEMICAL & ENGINEERING NEWS

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JULY 27, 1987

News of the Week

■ **International Trade Commission once again weighs dropping synthetic organic chemicals report, concerned by its cost, in time and money.** **Page 4**

■ **NASA considers several options in establishing long-range goals for its space program.** **Page 5**

■ **Second-quarter 1987 chemical earnings are generally up; pattern of gains is mixed.** **Page 5**

■ **Opponents and proponents of acid rain control measures have found several areas of agreement that may resolve Congressional impasse on this issue.** **Page 6**

■ **Trade and competitiveness bill is passed by the Senate, with a number of provisions important to the chemical industry.** **Page 6**

Business

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ACS News

Council will face two petitions—on "other committees" and resolution of election disputes—at its meeting in New Orleans. **Page 68**

Cover: Merck researcher devises process for producing potential new drug

Special Report

C&EN's annual compilation of data on research and development reveals that U.S. chemical R&D is growing modestly, with total expenditures expected to top $122 billion in 1987. **Page 32**

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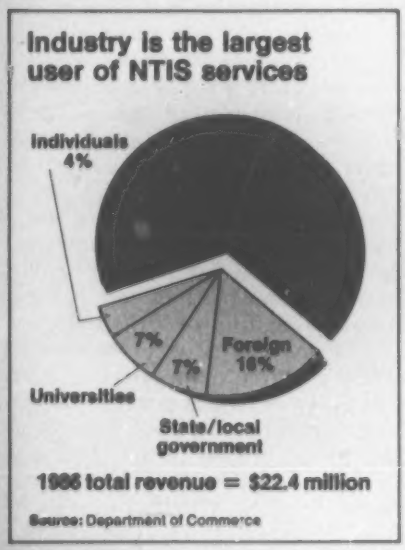
House panel criticizes privatization of NTIS

David J. Hanson, C&EN Washington

The National Technical Information Service will not be run by a private contractor anytime soon if Congress has any say over it. However, U.S. science and technology information policy needs a major facelift. Thus concluded the House Subcommittee on Science, Research & Technology after two-day hearings.

The hearings focused on two issues—general organization and distribution of information in the broad sense, and the proposed privatization of the National Technical Information Service.

Finding new and better mechanisms for getting scientific and technical information into the hands of people who can use it is being viewed as a partial solution to the U.S.'s economic competitiveness problems. Within the executive branch, the drive for better information policies comes from an April 10 Presidential executive order. That order, No. 12591, in part directs the National Science Foundation, the State Department, and the Commerce Department to develop "a central mechanism for the prompt and efficient dissemination of science and technology information developed abroad to users in federal laboratories, academic institutions, and the private sector on a fee-for-service basis."



But this is not the only movement under way to improve federal information services. Rep. George E. Brown Jr. (D.-Calif.) has introduced H.R. 1615, which would create a comprehensive Government Information Agency to oversee all federal information activities. The Department of Energy has begun a program of its own to improve information flow among its laboratories and researchers. And several agencies are trying to increase their access to foreign information, particularly from Japan.

The greatest attention, however, has been given to Administration efforts to turn NTIS over to the private sector. NTIS is not now a big office in the federal bureaucracy. It employs just 335 people and has a fiscal 1988 budget of about $36 million. It was established 42 years ago as a government clearinghouse for the collection and distribution of information. It also collects reports from Western European nations and has additional duties under the 1986 Japanese Technical Literature Act.

By all accounts, it has performed its functions well. In 1986 NTIS distributed about 20,000 information items to customers every day. It is seen as a major and reliable source for private industry and researchers of technical information and reports generated by federal agencies. This function is entirely self-supporting and generated about $22 million last year.

But a major tenet of the Reagan Administration is that the government is not in business to do business. The rationale is that private-sector companies can provide the same services at less cost than can the government. So agencies that sell government-generated products are targets for privatization. NTIS has been under the gun for some time, the idea first having come up in 1981. Last year the Commerce Department asked for public comments on privatization of NTIS, and many librarians and researchers responded that they did not think it was a good idea.

Proponents of the idea, almost entirely from within the Administration, claim that NTIS has been losing revenue of late because it has had to charge higher prices and because sales have been lower. So this year, the President's fiscal 1988 budget proposed that the private sector be given an opportunity to operate NTIS, with the government retaining overall control of policy.

C&EN staff photo

Walgren: NTIS has a library function

Commerce is exploring two methods for privatizing NTIS. The first is to have an outside contractor operate NTIS. The contractor would keep most of the revenue generated from selling federal information and would return to the government only enough to pay for agencies' turning over documents to NTIS. More than 30 potential bidders for NTIS met with Commerce officials June 16 to get more information.

The second idea, also described at the June meeting, is a plan called Federal Employees Direct Corporate Ownership Opportunity Plan, or FED COOP. The FED COOP idea is currently favored by the Administration. According to David S. Nathan, Commerce's deputy assistant secretary for special projects, it would have the contractor offer jobs to current NTIS employees and would offer employees stock in the new firm created by the contractor. Six-month employment would be guaranteed current workers. For the

Administration, one attraction of this plan is that no legislation is believed needed to carry it out. It could be done under the Office of Management & Budget Circular A-76, which is used for other federal contracting to private industry.

But many users of NTIS are concerned that privatization would cause major problems. Rep. Doug Walgren (D.-Pa.), chairman of the science subcommittee, has introduced a bill, H.R. 2159, that would convert NTIS into a government corporation. Walgren also inserted into the National Bureau of Standards fiscal 1988 authorization bill, H.R. 2160, an amendment that would prohibit NTIS from contracting out any more of its work than it already has. It would also prevent any transfer of NTIS out of the federal government without legislation.

"NTIS is essentially a library function," Walgren says. "There is a reason why most of the libraries in this nation are charitable and not for profit, and that is because if the profit motive decides what is to be done in the library function, you will have improper emphasis given to certain kinds of information that may not presently be appreciated in the marketplace, but may be literally critical to be accessed by various users of information."

Members of the information industry, however, are concerned about the formation of a government corporation. They view it as potential competition to their own activities. James V. Seals, director of marketing and corporate development for the American Chemical Society's Chemical Abstracts Service, told the subcommittee that the definition used for "government information" could be stretched to include scientific research performed with federal funds. If a government information agency were to start distributing the results of such research, it would compete directly with private information services such as CAS. He also thinks the government corporation would duplicate other private-sector services, citing the development of the STN International database collection, which includes direct on-line scientific information from Western Europe and soon from Japan.

Brown: federal information neglected

Other speakers at the hearings had different objections to the privatization of NTIS. Kenneth B. Allen, vice president of government relations for the Information Industry Association, told the subcommittee that any contractor that took over NTIS would be running a big risk. It would not be able to protect its holdings by copyright and might not receive many of the government documents now going to NTIS. The result would be a gradual erosion of NTIS files.

John Shattuck, vice president for government, community, and public affairs for Harvard University, voiced similar reservations about NTIS privatization. Speaking on behalf of the Association of American Universities and the Association of Research Libraries, he said there is considerable fear in the research community that such a move would mean the loss of foreign research reports, increased prices for documents, commercially driven decisions about collections and services, and increasing pressure to delete sensitive but unclassified technical information from the NTIS database.

The one alternative to the present NTIS program that seemed to grab the subcommittee's interest was the suggestion from Ralph E. Kinnickell Jr., public printer of the U.S., that NTIS be transferred to the Government Printing Office. As head of GPO, Kinnickell says he has im-

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proved the marketing strategy for government publications and has been able to return a "sizable surplus" to the Treasury. Kinnickell says the Superintendent of Documents Office at GPO already is doing much of what H.R. 1615 wants in the way of providing government information to the public. "The combination of GPO's size and NTIS's specialized skills can lead only to a more informed public," he concluded. Because GPO is under control of Congress and not the White House, as is the Department of Commerce, Congressmen seemed especially intrigued by the possibility of this kind of switch.

Despite the flurry of attention given NTIS, it is only one of hundreds of offices and agencies that distribute government information. The lack of any coordination among these is a main reason for Brown's attempt to set up a governmentwide office in H.R. 1615. "Federal information has not been properly managed," Brown says. "It has been neglected and overlooked to the extent that many members of both the Administration and Congress have suddenly realized that federal information is vital not only to our defense but to our economy and health." Although witnesses at the hearings related anecdotes about data collection through foreign service science officers of the State Department and of efforts to coordinate data among other agencies, it was clear there was little governmentwide cooperation.

Brown and Walgren were not convinced by arguments from the Administration that NTIS needs to be privatized. They see the federal role in distributing information as a service crucial to U.S. economic health. It is possible that private information services, such as STN International, will be able to do the job of organizing the vast amount of available government scientific and technical information better than the type of federal agency proposed in H.R. 1615, but that remains to be seen. Regardless of how information may be coordinated in the future, Congress and those that use the information are determined to keep NTIS part of the government for now. □

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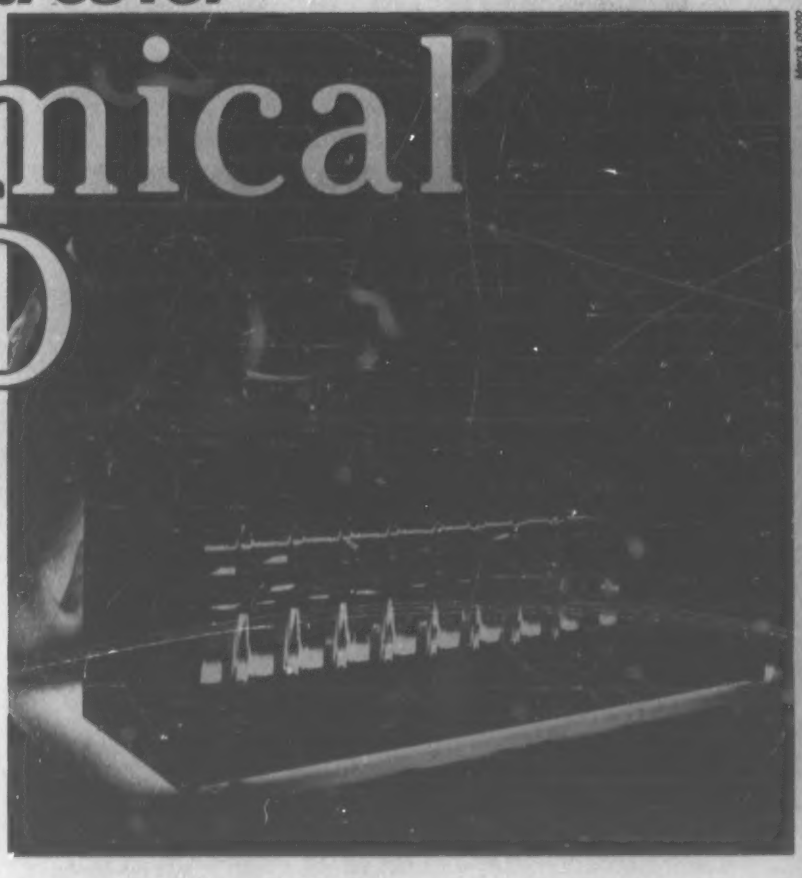
SPECIAL REPORT

Facts & Figures for Chemical R&D



Merck photo

Rebecca L. Rawls, C&EN Washington

Research and development in the U.S. is growing modestly. Total expenditures for R&D are expected to top $122 billion in 1987, an increase of 6% over R&D spending from all sources last year. That's the smallest year-to-year change in the past decade, a decade that has seen R&D funding nearly triple, in current dollars, from 1977's $42.8 billion. For the decade as a whole, R&D spending in the U.S. has been growing 11% per year—nearly twice the rate at which it is growing now.

Still, although significantly more modest than in the recent past, the increase in R&D funding expected this year does represent real growth, outpacing anticipated inflation by some 2%. In keeping with the recent pattern, about half that money comes from the federal government—$60 billion in 1987—and almost all the rest from industry. Universities and other nonprofit institutions will kick in a relatively modest $4.2 billion, only 3% of the total, this year.

Government spending for R&D is actually growing a good deal

1 *Overview*

A look at the total U.S. R&D effort. Where funds come from, who spends them, and how they are divided among basic and applied research and development. Who gets U.S. patents 35

2 *Federal Government*

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Ethyl photo

faster than federal spending as a whole. If Gramm-Rudman deficit reduction targets are to be met in this year's budget—an event that most observers consider unlikely--the overall federal budget probably will rise only a very modest 1% for the year ending Sept. 30. Federal R&D support, by contrast, is expected to be up 7% for 1987 as a whole. In general, the Reagan Administration and Congress have been relatively kind to R&D budgets during the past seven years, doubling federal support for R&D from its pre-Reagan level of $29.5 billion in 1980. Even when inflation is taken into account, federal R&D support has grown 46% since 1980.

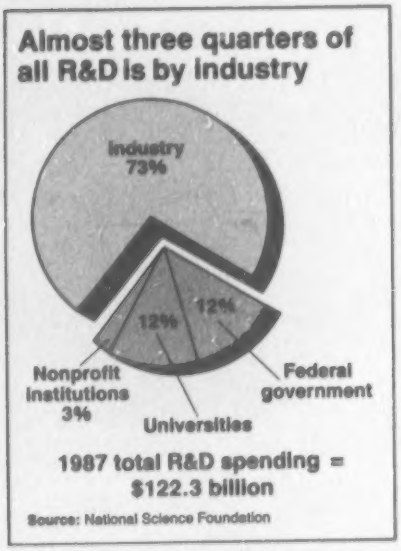
Until recently, industrial support for R&D has kept pace with the federal effort. In 1986 and again in 1987, however, preliminary figures indicate that industry's support for R&D is lagging behind that of government. R&D spending by all industry is expected to rise 5% this year, following a 6% increase in 1986 and one of 7% in 1985. Federal support over the same period rose, on average, 10% per year.

Considered in a broader context, however, current levels of support for R&D in the U.S. are quite high. R&D spending appears to be leveling off at about 2.7% of gross national product. For most of the past two decades it has been considerably lower than that, reaching its most recent nadir in 1978 at just above 2.1%. Not since the mid-1960s, when massive efforts in space and defense led the federal government to spend twice what industry did to support R&D, has such a large fraction of the nation's total output of goods and services, as measured by GNP, been devoted to supporting R&D. Though the rate of growth may be declining, overall support for R&D in the U.S. appears strong.

Chemical R&D, of course, is only a small piece of the total R&D picture. Just how much of the total national effort focuses on chemistry is never easy to measure, in part because the point where chemical R&D breaks off and R&D begins in some closely related field—materials science, say, or biotechnology—has never been clearly defined.

This year, separating out that part of the overall R&D effort that can reasonably be called chemical is even harder than usual. That's because some of the key data, particularly on the industrially financed half of the R&D picture, have yet to be compiled by the National Science Foundation. NSF is the chief source of statistical information on R&D in the U.S., and its data—collected in large part by the Census Bureau—form much of the basis of this special report. Recent reorganizations at both the Census Bureau and NSF's division of science resources studies have delayed the compilation of some of these data by three or four months. As a result, the most recent data available for many aspects of industrial R&D spending are based on information collected in 1983, too long ago to give a precise picture of the state of that R&D effort now.

Of the federally funded half of U.S. R&D, the biggest share—69% for the 1987 fiscal year—is funded by the Defense Department. Defense's share of the federal R&D budget has been climbing steadily in recent years, from a level of about 45% that prevailed throughout the late 1970s. That shift parallels another one that is taking place, name-

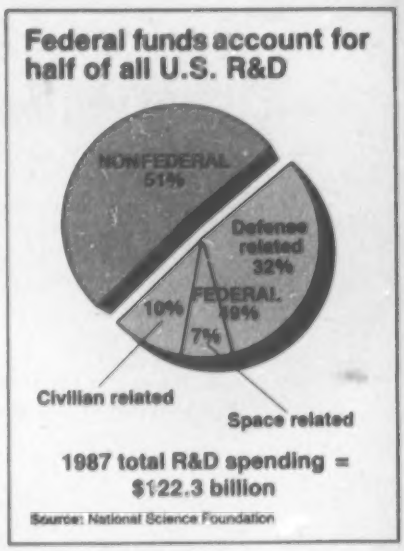


ly that more and more federal funds are going into the development part of R&D—72% in 1987, up from 64% five years ago. The Defense Department is the overwhelming source of federal development funds, supplying almost 90% in 1987.

Chemical research also finds its single largest federal patron in the Defense Department, which in the 1987 budget year is expected to spend $185 million for it. That's 28% of total federal chemical research support, which is estimated to reach $671 million. Defense Department support is up 10% from 1986 levels. Growing even faster is support from the National Science Foundation, which expects a 17% boost in its funding for chemical research in fiscal 1987. That would bring its support to $132 million, nearly to the level of the second largest supporter of chemical research in the federal government—the Department of Energy, which expects to spend $139 million on such research in fiscal 1987, down 6% from 1986. In fact, except for the Defense Department and NSF, all the major supporters of chemical research in the federal government will decrease their spending in this area in 1987. The net effect is a 3% rise overall for federal support for chemical research—no change at all when inflation is taken into account.

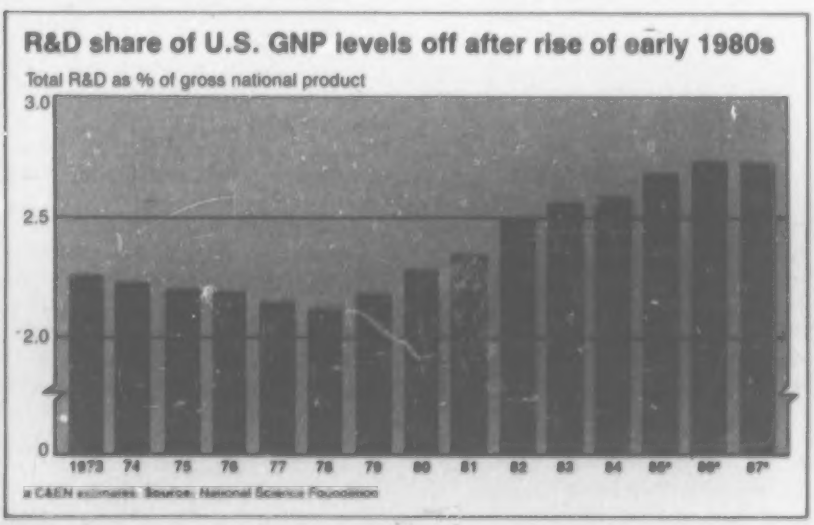
At universities, where half of the nation's basic research is performed, overall budgets for basic research were up a healthly 8% in 1986. Funds for applied R&D, which together account for only a third of total R&D spending at universities, also were up 8% in 1986. Spending at universities on chemical R&D reached $450 million in 1986, also an 8% hike from 1985. The federal government is the principal funder of university R&D—supplying nearly two thirds of the $11.1 billion universities expect to spend on R&D in 1987.

Though universities have a major role in performing basic research in the U.S., they trail far behind industry when it comes to carrying out applied research or development. In fact, industry will do 73% of the total R&D conducted in the U.S. this year, a fraction that has held essentially constant for the past decade. Universities and government-run R&D facilities each perform about equal shares of the remainder.



Historically, the overall chemicals and allied products industry performs about 70% of all the applied R&D done on chemicals or drugs by industry. R&D performed by companies in the chemicals and allied products industry is estimated to have increased 10% in 1986 to $9.5 billion. That level of growth is off a bit from the 12% average annual rate of increase for the past decade. When adjusted for inflation, however, the real growth in spending for 1986, at 7%, is slightly better than the 6% annual rate for the decade as a whole.

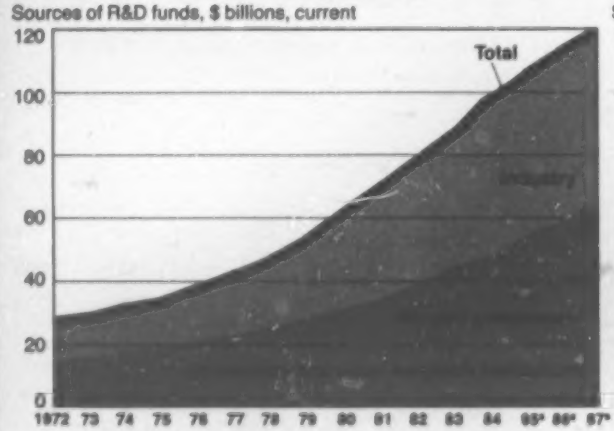
Growth in R&D at major industrial chemical companies was not so high as that for the chemicals and allied products industry as a whole in 1986—up only 4%. Some of this difference comes about because drug companies, which are part of the chemicals and allied products industry, are increasing their R&D spending faster than are basic chemical companies. Another contributing factor is a major divestment that took place at Union Carbide in 1986. The company sold off nearly $2 billion of its assets, largely in consumer products fields. The much smaller Union Carbide spent less on R&D in 1986 than its predecessor company had in 1985. When this change is taken into account, major chemical company R&D spending rose 7% in 1986. □


R&D share of U.S. GNP levels off after rise of early 1980s
Total R&D as % of gross national product
3.0
2.5
2.0
0
1973 74 75 76 77 78 79 80 81 82 83 84 85* 86* 87*
* C&EN estimates. Source: National Science Foundation

R&D • Overview

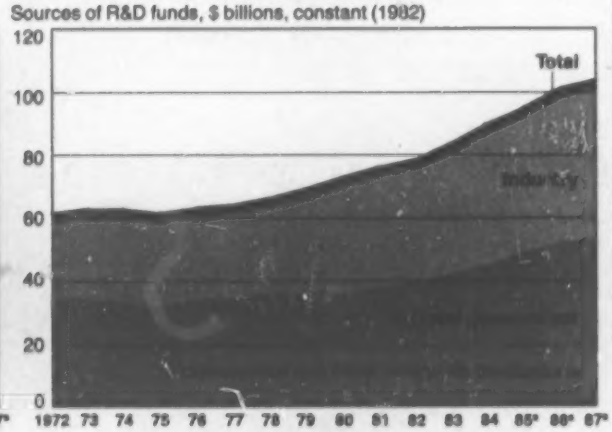
Although U.S. outlays for R&D are up fourfold in the past 15 years . . .

Sources of R&D funds, $ billions, current



. . . they are only two thirds higher if inflation is taken into account

Sources of R&D funds, $ billions, constant (1982)



a C&EN estimates. Source: National Science Foundation

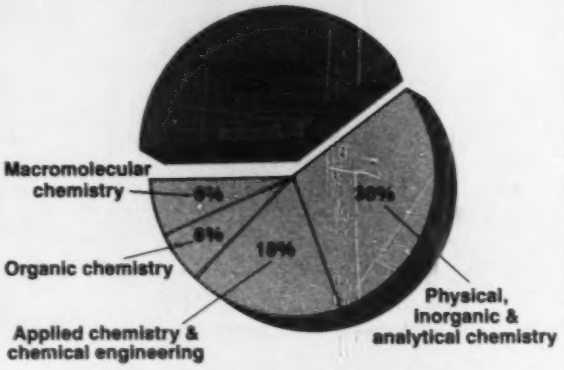
SOURCES OF R&D FUNDS: Industry and federal government each contribute nearly half

	$ Billions (current)											Annual change	
	1987*	1986*	1985*	1984	1983	1982	1981	1980	1979	1978	1977	1986–87	1977–87
Industry	$ 58.1	$ 55.3	$ 52.2	$48.8	$43.5	$40.1	$35.9	$30.9	$26.1	$22.5	$19.6	5%	11%
Federal government	60.0	56.0	51.8	45.6	40.7	36.5	33.4	29.5	26.8	23.9	21.6	7	11
Universities and colleges	2.7	2.5	2.3	2.0	1.9	1.7	1.5	1.3	1.2	1.0	0.9	8	12
Other nonprofit institutions	1.5	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7	7	8
TOTAL	$122.3	$115.2	$107.5	$97.6	$87.2	$79.3	$71.8	$62.6	$54.9	$48.1	$42.8	6%	11%
ANNUAL CHANGE	6%	7%	10%	12%	10%	10%	15%	14%	14%	12%	10%		

	$ Billions (1982, constant)												
Industry	$ 48.8	$ 48.3	$46.8	$45.2	$41.9	$40.1	$38.3	$36.1	$33.2	$31.1	$28.2	1%	5%
Federal government	50.4	48.9	46.5	42.3	39.2	36.5	35.7	34.5	34.3	33.2	31.2	3	5
Universities and colleges	2.3	2.2	2.1	1.9	1.8	1.7	1.6	1.6	1.5	1.4	1.3	5	6
Other nonprofit institutions	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.1	1.1	1.1	1.0	8	3
TOTAL	$102.7	$100.6	$96.4	$90.5	$83.9	$79.3	$76.6	$73.2	$70.1	$66.8	$63.7	2%	5%
ANNUAL CHANGE	2%	4%	7%	8%	6%	4%	5%	4%	5%	5%	2%		

a C&EN estimates. Source: National Science Foundation

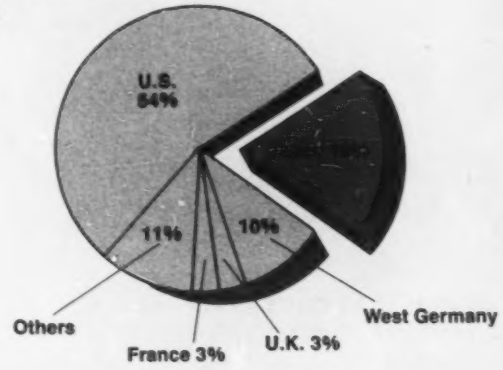
Two fifths of chemistry papers are in biochemistry



1986 total papers[a] = 474,429

a Number of abstracts of papers published in *Chemical Abstracts*.
Source: Chemical Abstracts Service

Japanese now receive nearly 20% of U.S. patents



1986 total U.S. patents issued = 70,860

Source: U.S. Patent & Trademark Office

PERFORMERS OF R&D: Industry's share is six times that of government

	$ Billions (current)											Annual change	
	1987[a]	1986[a]	1985[a]	1984	1983	1982	1981	1980	1979	1978	1977	1986–87	1977–87
Industry	$ 88.7	$ 84.4	$ 78.2	$71.5	$63.4	$58.0	$51.8	$44.5	$38.2	$33.3	$29.8	5%	12%
Federal government	15.1	13.4	13.0	11.6	10.6	9.1	8.4	7.6	7.4	6.8	6.0	13	10
Universities and colleges	10.7	10.3	9.5	8.5	7.8	7.3	6.8	6.1	5.4	4.6	4.1	4	10
University-associated FFRDCs[b]	4.0	3.8	3.5	3.1	2.7	2.5	2.5	2.2	1.9	1.7	1.4	5	11
Other nonprofit institutions	3.7	3.4	3.3	3.0	2.7	2.4	2.3	2.2	2.0	1.7	1.5	9	9
TOTAL	**$122.3**	**$115.2**	**$107.5**	**$97.6**	**$87.2**	**$79.3**	**$71.8**	**$62.6**	**$54.9**	**$48.1**	**$42.8**	**6%**	**11%**
	$ Billions (1982, constant)												
Industry	$ 74.5	$ 73.7	$70.1	$66.9	$61.0	$58.0	$55.1	$51.9	$48.7	$46.1	$44.3	1%	5%
Federal government	12.7	11.7	11.7	10.8	10.2	9.1	9.0	9.0	9.5	9.5	9.0	9	4
Universities and colleges	9.0	9.0	8.5	7.9	7.5	7.3	7.3	7.2	6.9	6.4	6.1	0	4
University-associated FFRDCs[b]	3.4	3.3	3.1	2.9	2.6	2.5	2.7	2.7	2.5	2.4	2.1	3	5
Other nonprofit institutions	3.1	3.0	3.0	2.8	2.6	2.4	2.4	2.5	2.5	2.3	2.2	3	3
TOTAL	**$102.7**	**$100.6**	**$96.4**	**$90.5**	**$83.9**	**$79.3**	**$76.6**	**$73.2**	**$70.1**	**$66.8**	**$63.7**	**2%**	**5%**

a C&EN estimates. b Federally funded R&D centers. Those administered by both industry and by nonprofit institutions are included in totals for their respective sectors.
Source: National Science Foundation

CHARACTER OF R&D: Uniform growth in all three sectors

	$ Billions (current)											Annual change	
	1987[a]	1986[a]	1985[a]	1984	1983	1982	1981	1980	1979	1978	1977	1986–87	1977–87
Basic research	$ 14.7	$ 13.8	$ 13.0	$12.1	$11.0	$ 9.9	$ 9.2	$ 8.1	$ 7.3	$ 6.4	$ 5.5	7%	10%
Applied research	26.4	24.7	23.4	22.3	20.4	18.5	16.9	14.1	12.3	10.8	9.7	7	11
Development	81.2	76.5	71.1	62.9	55.8	50.9	45.8	40.5	35.3	30.9	27.5	6	11
TOTAL	**$122.3**	**$115.2**	**$107.5**	**$97.6**	**$87.2**	**$79.3**	**$71.8**	**$62.6**	**$54.9**	**$48.1**	**$42.8**	**6%**	**11%**
	$ Billions (1982, constant)												
Basic research	$ 12.3	$ 12.1	$11.7	$11.2	$10.6	$ 9.9	$ 9.8	$ 9.5	$ 9.3	$ 8.9	$ 8.3	2%	4%
Applied research	22.2	21.6	21.0	20.7	19.6	18.5	18.0	16.5	15.8	15.1	14.5	3	4
Development	68.2	66.8	63.8	58.3	53.7	50.9	48.8	47.3	45.0	42.8	40.9	2	5
TOTAL	**$102.7**	**$100.6**	**$96.4**	**$90.5**	**$83.9**	**$79.3**	**$76.6**	**$73.2**	**$70.1**	**$66.8**	**$63.7**	**2%**	**5%**

a C&EN estimates. Source: National Science Foundation

PATENT ACTIVITY OF U.S. COMPANIES:[a] Significant decline for chemicals in 1986

Number of patents issued	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	Total 1977–86
CHEMICAL COMPANIES											
Dow Chemical	371	335	328	246	276	260	249	217	334	297	**2,913**
Du Pont	329	342	348	326	283	343	289	227	386	431	**3,304**
Ciba-Geigy	244	305	290	244	281	345	309	248	347	354	**2,967**
Union Carbide	208	242	231	182	202	262	211	197	215	224	**2,174**
PPG Industries	124	128	137	137	177	189	166	118	190	196	**1,582**
Monsanto	110	100	138	136	131	211	205	144	264	192	**1,631**
American Cyanamid	92	115	111	128	129	188	205	143	225	215	**1,551**
Olin	81	117	112	85	80	80	106	82	99	91	**933**
Ethyl	77	105	76	44	31	43	51	25	41	46	**539**
International Flavors & Fragrances	76	104	95	87	87	96	76	60	80	52	**813**
Stauffer Chemical	75	104	95	81	87	94	93	80	132	116	**957**
Celanese	66	67	94	57	56	58	56	44	71	70	**639**
Hercules	43	41	39	37	30	52	23	24	49	51	**389**
W. R. Grace	42	45	57	52	49	68	72	56	76	63	**580**
Rohm & Haas	33	31	37	55	49	77	74	77	95	94	**622**
GAF	12	23	19	21	32	47	48	54	57	26	**339**
TOTAL[b]	**1983**	**2204**	**2207**	**1918**	**1980**	**2413**	**2233**	**1796**	**2661**	**2518**	**21,913**
ANNUAL CHANGE	**−10%**	**0%**	**15%**	**−3%**	**−18%**	**8%**	**24%**	**−33%**	**6%**	**−9%**	

a Includes U.S. chemical companies or U.S.-based subsidiaries of foreign companies that have received more than 999 U.S. patents since 1962. b These totals include patents issued to the chemical companies shown in this table only. **Source:** U.S. Patent & Trademark Office

U.S. PATENTS: Those of foreign origin rose 2% in 1986 as those of U.S. origin declined 4%

Number of patents issued	1986	1985	1984	1983	1982	1981	1980	1979[a]	1978	1977	Total 1977–86
U.S. origin	**38,124**	**39,554**	**38,365**	**32,871**	**33,896**	**39,223**	**37,356**	**30,079**	**41,254**	**41,485**	**372,207**
to U.S. corporations	27,324	28,944	28,002	24,038	24,085	27,623	25,967	21,145	29,421	29,566	**266,115**
to U.S. government	1,011	1,124	1,228	1,043	1,003	1,117	1,232	961	1,233	1,484	**11,436**
to individuals in the U.S.	9,461	9,243	8,887	7,562	8,539	10,241	9,940	7,804	10,399	10,249	**92,325**
to foreign-owned corporations in the U.S.	328	243	248	228	269	242	217	169	201	186	**2,331**
Foreign origin	**32,736**	**32,107**	**28,835**	**23,989**	**23,992**	**26,548**	**24,463**	**18,775**	**24,848**	**23,784**	**260,077**
to U.S.-owned corporations abroad	2,231	2,274	2,032	1,660	1,715	1,839	1,694	1,364	1,961	1,970	**18,740**
to foreign corporations	26,196	25,721	22,985	19,019	18,589	20,549	18,665	14,447	18,875	17,879	**202,925**
to foreign governments	471	483	440	336	368	249	253	186	249	215	**3,250**
to foreign individuals	3,838	3,629	3,378	2,974	3,320	3,911	3,851	2,778	3,763	3,720	**35,162**
TOTAL	**70,860**	**71,661**	**67,200**	**56,860**	**57,888**	**65,771**	**61,819**	**48,854**	**66,102**	**65,269**	**632,284**
% FOREIGN	**46.2%**	**44.8%**	**42.9%**	**42.2%**	**41.4%**	**40.4%**	**39.6%**	**38.4%**	**37.6%**	**36.4%**	**41.1%**

a Patent figures were low in 1979 because the U.S. Patent & Trademark Office was short of funds to print patents it might otherwise have issued. **Source:** U.S. Patent & Trademark Office

HOLDERS OF U.S. PATENTS: Japan's share doubles in past decade

% of patents	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	Total 1977–86	Total 1963–76
U.S. origin	**54**	**55**	**57**	**58**	**59**	**60**	**60**	**62**	**62**	**64**	**59**	**73**
Foreign origin[a]	**46**	**45**	**43**	**42**	**41**	**40**	**40**	**38**	**38**	**36**	**41**	**27**
Japan	19	18	17	15	14	13	12	11	10	10	14	5
West Germany	10	9	9	10	9	10	9	9	9	8	9	7
U.K.	3	3	3	3	4	4	4	4	4	4	4	4
France	3	3	3	3	3	3	3	3	3	3	3	3
Switzerland	2	2	2	2	2	2	2	2	2	2	2	2
Canada	2	2	2	2	2	2	2	2	2	2	2	2
Sweden	1	1	1	1	1	1	1	1	1	1	1	1
Italy	1	1	1	1	1	1	1	1	1	1	1	1
Netherlands	1	1	1	1	1	1	1	1	1	1	1	1
U.S.S.R.	—	—	—	—	—	1	1	1	1	1	—	—
Others	2	—	—	—	—	—	—	—	—	—	3	2

a Data for individual countries may not equal this number because of rounding. **Source:** U.S. Patent & Trademark Office

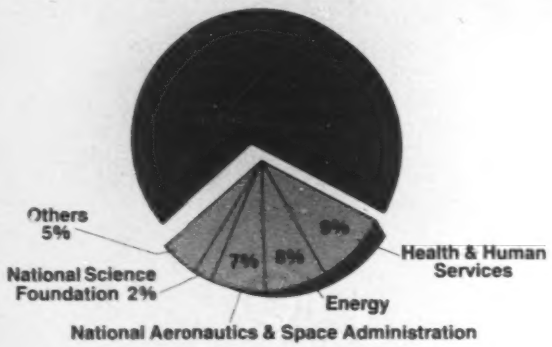
ABSTRACTS OF PAPERS IN *CHEMICAL ABSTRACTS:* Biochemistry's share holds steady at 40%

	1986	1985	1984	1983	1982	1981	1976	Percentage point change, 1976–86
BIOCHEMISTRY	40.4%	40.5%	40.5%	38.3%	39.5%	39.0%	38.8%	1.6%
			% of all biochemistry abstracts					
Mammalian hormones[a]	12.5%	12.3%	12.4%	12.9%	12.2%	6.8%	5.9%	6.6%
Pharmacology	12.2	12.3	11.6	11.8	12.0	12.4	12.0	0.2
Mammalian biochemistry[a]	10.8	11.1	11.3	11.1	11.6	15.6	16.3	−5.5
Toxicology	7.8	7.9	8.0	8.5	8.1	8.7	6.4	1.4
Immunochemistry	6.1	5.3	4.8	4.2	4.4	3.4	—	—
Biochemical genetics[b]	6.1	5.2	4.2	3.8	3.3	—	—	—
Microbial biochemistry[a]	5.7	5.7	5.2	5.1	5.3	5.6	5.0	0.7
Enzymes	5.6	5.6	5.8	6.1	5.9	5.9	6.4	−0.8
Plant biochemistry[a]	5.2	5.5	6.2	5.9	6.2	5.8	6.1	−0.9
Biochemical methods	5.0	4.9	4.9	4.9	4.6	5.7	—	—
General biochemistry	4.7	4.9	5.3	5.8	6.0	7.5	7.1	−2.4
Others	18.3	19.3	20.3	19.9	20.4	22.6	34.8	—
PHYSICAL, INORGANIC, AND ANALYTICAL CHEMISTRY	29.8	29.8	28.8	29.6	28.5	28.0	27.5	2.3
			% of all physical, inorganic, and analytical chemistry abstracts					
Spectra	20.0	18.4	18.0	17.6	17.2	18.0	17.8	2.2
Nuclear chemistry	19.9	21.8	22.2	22.5	22.6	21.6	19.7	0.2
Electric phenomena	10.8	10.8	10.8	10.0	10.5	11.0	10.5	0.3
Crystallography and liquid crystals	7.0	7.5	7.8	8.3	8.7	8.9	9.7	−2.7
General physical chemistry	7.0	6.9	6.9	7.3	7.3	7.2	7.0	0.0
Analytical chemistry	6.8	6.1	6.3	6.2	5.4	5.8	6.6	0.2
Others	28.5	28.5	28.0	28.1	28.3	27.5	28.7	−0.2
APPLIED CHEMISTRY AND CHEMICAL ENGINEERING	18.2	18.4	17.6	19.4	19.5	19.1	18.8	−0.6
			% of all applied chemistry and chemical engineering abstracts					
Water, wastes, and pollution	21.9	20.2	21.0	19.6	21.7	24.0	18.6	3.3
Metals and alloys	20.8	20.0	18.9	19.1	22.2	17.9	27.8	−7.0
Mineralogical and geological chemistry	12.0	12.5	14.6	14.1	13.6	14.1	17.6	−5.6
Fossil fuels, derivatives, and related products	9.0	10.1	10.1	10.3	9.4	9.4	6.0	3.0
Unit operations and processes	7.1	7.5	7.0	7.5	6.9	6.4	4.8	2.3
Others	29.2	29.7	29.4	29.4	26.2	28.2	25.2	4.0
ORGANIC CHEMISTRY	5.9	6.4	7.6	7.3	7.2	8.7	8.7	−2.8
			% of all organic chemistry abstracts					
Physical organic chemistry	27.3	30.6	32.0	30.5	31.5	37.0	38.4	−11.1
Organometallic and organometalloidal compounds	18.3	16.2	17.1	16.3	14.8	8.3	8.7	9.6
Heterocyclic compounds[a]	15.0	16.1	15.6	16.2	15.6	18.2	17.4	−2.4
Carbohydrates	7.8	5.7	5.7	5.8	5.8	5.4	5.1	2.7
Aromatic compounds[a]	7.3	6.3	6.3	7.1	7.2	8.7	8.0	−0.7
Biomolecules and their synthetic analogs[b]	5.0	4.9	4.4	4.5	3.7	—	—	—
Aliphatic compounds[a]	4.4	4.2	3.6	4.3	5.2	6.6	6.5	−2.1
Amino acids, peptides, and proteins[a]	3.9	4.6	4.8	4.5	4.4	4.2	4.3	−0.4
Others	11.0	11.4	10.5	10.8	11.8	11.6	11.6	—
MACROMOLECULAR CHEMISTRY	5.7	4.9	5.5	5.4	5.3	5.2	6.2	−0.5
			% of all macromolecular chemistry abstracts					
Synthetic high polymers	34.1	34.1	34.0	34.4	34.7	30.3	28.3	5.8
Plastics manufacture and uses	23.8	25.3	24.2	24.4	21.9	26.4	26.8	−3.0
Cellulose, lignin, paper, and other wood products	9.8	9.1	9.6	9.1	9.7	10.1	9.1	0.7
Textiles	8.8	8.2	7.3	7.9	8.9	9.9	11.1	−2.3
Coatings, inks, and related products	7.2	7.2	7.8	6.6	7.6	7.5	7.6	−0.4
Synthetic elastomers and natural rubber	6.7	6.8	7.3	7.5	7.8	7.9	8.6	−1.9
Others	9.6	9.3	9.8	10.1	9.4	7.9	8.5	1.1

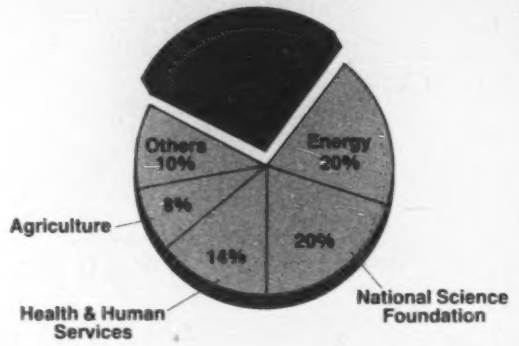
How to read this table: Using biochemistry as an example, 40.4% of all the papers abstracted by Chemical Abstracts Service in 1986 are in the various subdisciplines of biochemistry; 12.5% of all abstracts in biochemistry, in turn, are in the subdiscipline of mammalian hormones, 12.2% of biochemistry abstracts are in pharmacology, and so on. a Definition of section changed in 1982. b New section in 1982. **Source:** Chemical Abstracts Service

Defense's share of federal support grows

Defense gets nearly 70% of federal R&D funding but less than a third of funds for chemistry



Estimated fiscal 1987 total federal R&D obligations = $59.2 billion



Estimated fiscal 1987 federal chemistry research obligations = $671 million

Source: National Science Foundation

FEDERAL OBLIGATIONS FOR R&D: Up strongly thanks to big boost for military funds

$ Millions	1987[a]	1986[a]	1985	1984	1983	1982	Annual change 1986–87	Annual change 1982–87
Defense	**$40,678.8**	**$33,646.3**	**$29,791.5**	**$25,372.9**	**$22,992.8**	**$20,622.6**	**21%**	**15%**
Air Force	17,356.5	13,757.5	13,260.9	12,091.6	10,812.6	9,357.9	26	13
Navy	10,700.8	10,137.3	9,127.4	7,605.6	6,068.2	5,845.1	6	13
Army	5,710.2	4,850.2	4,570.8	4,225.5	3,998.1	3,760.5	18	9
Defense agencies[b]	6,775.3	4,790.7	2,781.7	1,391.5	2,052.3	1,618.1	41	33
Health & Human Services	**5,270.8**	**5,611.3**	**5,451.0**	**4,830.7**	**4,352.5**	**3,940.7**	**−6**	**6**
National Institutes of Health	4,672.3	4,977.3	4,827.7[a]	4,257.4	3,789.2	3,433.1	−6	3
Alcohol, Drug Abuse & Mental Health Administration	383.1	396.2	377.6	337.2	302.2	248.1	−3	9
Energy	**4,770.7**	**4,691.6**	**4,996.0**	**4,673.6**	**4,536.7**	**4,708.2**	**2**	**0**
National Aeronautics & Space Administration	**3,926.0**	**3,478.4**	**3,327.2**	**2,821.9**	**2,661.6**	**3,077.9**	**13**	**5**
National Science Foundation	**1,508.3**	**1,333.5**	**1,345.6**	**1,202.8**	**1,062.0**	**975.3**	**13**	**9**
Agriculture	**909.2**	**923.0**	**943.0**	**866.2**	**847.6**	**797.3**	**−1**	**3**
Agricultural Research Service	497.0	463.1	469.7	451.3	443.4	404.9	7	4
Cooperative State Research Service	234.4	263.1	284.3	235.7	232.3	219.0	−11	1
Forest Service	111.5	120.1	113.1	108.4	107.7	112.1	−7	0
Interior	**350.6**	**388.3**	**391.7**	**410.9**	**382.5**	**381.1**	**−10**	**−2**
Geological Survey	207.6	218.6	214.9	208.9	157.0	152.6	−5	6
Environmental Protection Agency	**309.6**	**333.6**	**320.4**	**261.2**	**240.7**	**335.1**	**−7**	**−2**
Commerce	**300.9**	**391.1**	**398.8**	**358.2**	**335.0**	**336.3**	**−23**	**−2**
National Oceanic & Atmospheric Administration	196.3	268.1	269.8	244.3	222.0	222.0	−27	−2
National Bureau of Standards	91.4	99.3	100.5	95.5	95.0	88.8	−8	1
Others	**1,184.7**	**1,264.7**	**1,367.1**	**1,426.5**	**1,300.1**	**1,258.1**	**−6**	**−1**
TOTAL	**$59,209.6**	**$52,061.8**	**$48,332.3**	**$42,224.9**	**$38,711.5**	**$36,432.6**	**14%**	**10%**
ANNUAL CHANGE	**14%**	**8%**	**14%**	**9%**	**6%**	**4%**		

Note: Fiscal years. a Estimated. b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, and others. Source: National Science Foundation

PERFORMERS OF FEDERALLY FUNDED RESEARCH: 54% is undertaken by industry

$ Millions	1987[a]	1986[a]	1985	1984	1983	1982	Annual change 1986–87	Annual change 1982–87
Industry	$31,787.9	$26,847.9	$23,774.3	$20,361.5	$18,649.0	$18,698.6	18%	11%
Federal intramural programs	15,396.7	13,533.4	12,998.4	11,572.3	10,581.9	9,141.0	14	11
Universities and colleges	6,558.7	6,554.7	6,299.0	5,565.1	4,966.4	4,605.5	0	7
University-associated FFRDCs[b]	2,712.8	2,446.2	2,534.5	2,324.9	2,265.8	1,976.7	11	7
Nonprofit institutions	2,451.3	2,318.1	2,365.0	2,094.4	1,822.9	1,612.3	6	9
Foreign	219.8	257.8	255.9	175.8	239.5	214.3	−15	1
State and local governments	82.4	103.6	105.2	130.9	186.0	184.3	−20	−15
TOTAL	**$59,209.6**	**$52,061.8**	**$48,332.3**	**$42,224.9**	**$38,711.5**	**$36,432.6**	**14%**	**10%**

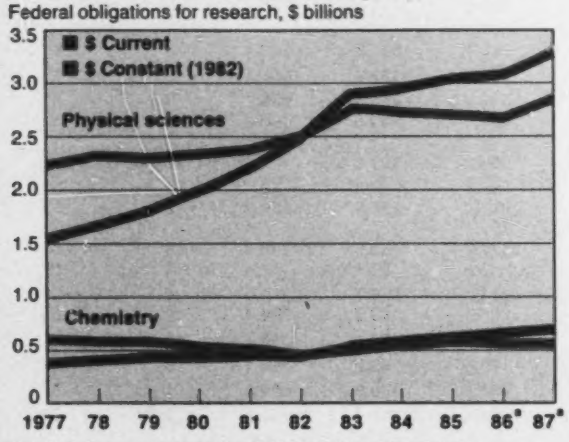
Note: Fiscal years. a Estimated. b Federally funded R&D centers. Those administered by both industry and by nonprofit institutions are included in totals for their respective sectors. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR SCIENTIFIC DISCIPLINES: Slow growth for chemistry this year

$ Millions for research only	1987[a]	1986[a]	1985	1984	1983	1982	Annual change 1986–87	Annual change 1982–1987
Life sciences	$ 6,289.2	$ 6,457.6	$ 6,366.2	$ 5,635.9	$ 5,177.9	$ 4,745.5	−3%	6%
Engineering	3,857.8	3,684.4	3,628.5	3,624.1	3,517.0	3,386.5	5	3
Chemical	186.0	243.5	254.1	144.5	145.0	95.1	−24	14
Metallurgy and materials	465.5	464.1	439.1	341.1	332.5	309.1	0	9
Physical sciences	3,300.3	3,071.8	3,044.0	2,969.0	2,891.4	2,500.4	7	6
Chemistry	670.9	653.4	644.5	606.4	520.3	481.2	3	7
Physics	1,965.4	1,829.4	1,820.0	1,836.4	1,854.6	1,610.5	7	4
Environmental sciences	1,483.4	1,458.2	1,403.6	1,275.9	1,251.2	1,148.3	2	5
Mathematics and computer sciences	759.0	665.0	577.5	440.3	419.4	350.1	14	17
Other sciences	1,151.4	1,117.7	1,110.3	1,033.6	996.6	891.4	3	5
TOTAL	$16,841.1	$16,454.7	$16,130.1	$14,978.8	$14,253.5	$13,022.2	2%	5%
ANNUAL CHANGE	2%	2%	8%	5%	9%	7%		

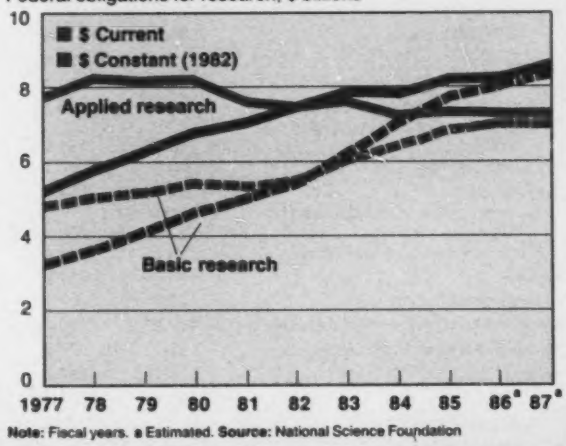
a Estimated. **Source:** National Science Foundation

Federal support for physical science little changed since 1983 in real dollars



Note: Fiscal years. a Estimated. **Source:** National Science Foundation

Government funding of basic research catching up with applied research support



Note: Fiscal years. a Estimated. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR BASIC RESEARCH: Little growth this year

$ Millions	1987[a]	1986[a]	1985	1984	1983	1982	Annual change 1986–87	Annual change 1982–1987
Health & Human Services	**$3162.4**	**$3357.1**	**$3232.5**	**$2814.5**	**$2475.4**	**$2144.7**	**−6%**	**8%**
National Institutes of Health	2938.3	3133.6	3018.0[a]	2624.8	2313.0	2020.7	−6	8
Alcohol, Drug Abuse & Mental Health Administration	204.4	206.2	196.8	170.8	145.0	117.3	−1	12
National Science Foundation	**1422.6**	**1255.7**	**1261.8**	**1132.3**	**999.1**	**916.1**	**13**	**9**
Energy	**1063.1**	**945.9**	**942.6**	**830.4**	**767.7**	**642.2**	**12**	**11**
Defense	**995.9**	**994.3**	**861.4**	**847.9**	**785.6**	**686.7**	**0**	**8**
Navy	385.6	350.5	343.1	315.8	305.4	280.3	10	7
Air Force	284.5	234.4	198.3	192.4	164.2	145.8	21	14
Army	249.3	242.4	240.8	222.1	208.3	187.7	3	6
Defense agencies[b]	76.5	167.0	79.2	117.6	107.7	72.9	−54	1
National Aeronautics & Space Administration	**986.1**	**850.4**	**750.9**	**754.5**	**617.0**	**535.7**	**16**	**13**
Agriculture	**434.1**	**432.7**	**445.4**	**392.6**	**362.0**	**330.8**	**0**	**6**
Agricultural Research Service	267.2	247.6	250.2	240.6	215.3	192.9	8	7
Cooperative State Research Service	115.8	126.2	141.5	99.6	98.8	91.3	−8	5
Forest Service	43.1	50.5	44.1	41.2	38.8	38.7	−15	2
Interior	**115.7**	**137.6**	**138.3**	**125.9**	**103.0**	**76.5**	**−16**	**9**
Geological Survey	79.5	83.4	80.5	78.9	64.7	52.6	−3	9
Environmental Protection Agency	**37.0**	**39.3**	**38.6**	**29.6**	**22.2**	**32.7**	**−6**	**3**
Commerce	**19.5**	**22.1**	**23.2**	**20.6**	**19.2**	**18.9**	**−12**	**3**
National Bureau of Standards	19.1	21.2	22.1	20.2	18.4	16.5	−10	3
National Oceanic & Atmospheric Administration	0	0	0	0	0	0	—	—
Others	**111.3**	**110.0**	**124.0**	**119.1**	**108.9**	**99.3**	**1**	**2**
TOTAL	**$8347.7**	**$8145.1**	**$7818.7**	**$7067.4**	**$6260.1**	**$5481.6**	**2%**	**9%**
ANNUAL CHANGE	**2%**	**4%**	**11%**	**13%**	**14%**	**9%**		

Note: Fiscal years. a Estimated. b Includes Defense Advanced Projects Agency, Defense Nuclear Agency, and others. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR APPLIED RESEARCH: Increases for Defense, NASA, and NSF

$ Millions	1987[a]	1986[a]	1985	1984	1983	1982	Annual change 1986–87	Annual change 1982–1987
Defense	**$2636.1**	**$2364.8**	**$2306.9**	**$2200.7**	**$2437.0**	**$2266.1**	**11%**	**3%**
Army	719.4	551.3	582.6	486.7	485.3	451.6	30	10
Air Force	562.2	573.4	538.4	547.7	524.2	488.1	−2	3
Navy	464.6	463.9	448.2	449.6	521.6	498.4	0	−1
Defense agencies[b]	889.9	776.2	737.7	716.6	905.9	828.1	15	1
Health & Human Services	**1724.0**	**1834.0**	**1795.8**	**1651.5**	**1545.4**	**1460.9**	**−6**	**3**
National Institutes of Health	1368.2	1452.8	1410.1[a]	1285.6	1165.2	1103.8	−6	4
Alcohol, Drug Abuse & Mental Health Administration	177.5	188.8	179.7	165.2	155.4	128.7	−6	7
National Aeronautics & Space Administration	**1396.5**	**1114.4**	**1032.7**	**954.7**	**927.8**	**871.4**	**25**	**10**
Energy	**913.3**	**1080.4**	**1198.4**	**1194.5**	**1193.4**	**1053.9**	**−15**	**−3**
Agriculture	**444.0**	**458.8**	**465.6**	**442.2**	**455.5**	**435.7**	**−3**	**0**
Agricultural Research Service	202.4	188.1	191.8	183.7	202.6	186.2	8	2
Cooperative State Research Service	118.7	136.9	142.8	136.2	133.5	127.7	−13	−1
Forest Service	65.4	66.7	65.7	63.9	65.1	69.0	−2	−1
Commerce	**236.7**	**304.4**	**301.0**	**276.1**	**265.6**	**259.2**	**−22**	**−2**
National Oceanic & Atmospheric Administration	163.8	229.7	224.4	197.7	188.9	188.5	−29	−3
National Bureau of Standards	63.5	65.6	64.5	63.5	63.1	57.4	−3	2
Interior	**210.9**	**227.5**	**231.0**	**254.3**	**254.7**	**275.0**	**−7**	**−5**
Geological Survey	118.2	127.8	130.0	125.1	89.9	99.4	2	6
Environmental Protection Agency	**170.0**	**180.4**	**176.0**	**142.3**	**152.4**	**210.7**	**−6**	**−4**
National Science Foundation	**85.7**	**77.8**	**83.8**	**70.5**	**62.9**	**57.1**	**10**	**8**
Others	**676.2**	**667.0**	**720.3**	**724.6**	**698.7**	**650.6**	**1**	**1**
TOTAL	**$8493.4**	**$8309.5**	**$8311.5**	**$7911.4**	**$7993.4**	**$7540.6**	**2%**	**2%**
ANNUAL CHANGE	**2%**	**0%**	**5%**	**−1%**	**6%**	**5%**		

Note: Fiscal years. a Estimated. b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, and others. **Source:** National Science Foundation

CIRCLE 31 ON READER SERVICE CARD

FEDERAL OBLIGATIONS FOR DEVELOPMENT: Nearly 90% goes for military work

$ Millions	1987[a]	1986[a]	1985	1984	1983	1982	Annual change 1986–87	Annual change 1982–87
Defense	**$37,046.8**	**$30,287.2**	**$26,623.2**	**$22,324.3**	**$19,770.1**	**$17,669.8**	**22%**	**16%**
Air Force	16,509.8	12,949.7	12,524.3	11,351.5	10,124.2	8,724.0	27	14
Navy	9,850.6	9,322.9	8,336.1	6,840.2	5,241.2	5,066.4	6	14
Army	4,741.6	4,056.6	3,747.4	3,516.8	3,304.5	3,121.3	17	9
Defense agencies[b]	5,808.9	3,847.5	1,964.8	557.3	1,038.7	717.1	51	52
Energy	**2,794.4**	**2,665.3**	**2,825.0**	**2,648.7**	**2,575.6**	**3,012.1**	**5**	**−1**
National Aeronautics & Space Administration	**1,543.4**	**1,513.6**	**1,543.6**	**1,112.7**	**1,116.8**	**1,670.7**	**2**	**−2**
Health & Human Services	**384.3**	**420.2**	**422.7**	**364.7**	**331.7**	**335.2**	**−9**	**3**
National Institutes of Health	365.8	390.9	399.6[a]	347.0	311.0	308.7	−6	3
Alcohol, Drug Abuse & Mental Health Administration	1.2	1.2	1.1	1.2	1.8	2.1	0	−11
Environmental Protection Agency	**102.6**	**113.9**	**105.8**	**89.2**	**66.1**	**91.7**	**−10**	**2**
Commerce	**44.7**	**64.6**	**74.6**	**61.5**	**50.2**	**80.2**	**−31**	**−6**
National Oceanic & Atmospheric Administration	32.5	38.4	45.4	46.6	33.1	33.5	−15	−1
National Bureau of Standards	8.8	12.5	14.0	11.8	13.6	14.9	−30	−10
Agriculture	**31.1**	**31.5**	**32.0**	**31.3**	**30.0**	**30.8**	**−1**	**0**
Agricultural Research Service	27.4	27.4	27.7	27.0	25.5	25.8	0	1
Forest Service	3.0	2.9	3.3	3.3	3.8	4.5	3	−8
Cooperative State Research Service	0	0	0	0	0	0	—	—
Interior	**24.0**	**23.2**	**22.4**	**30.7**	**24.8**	**29.6**	**3**	**−4**
Geological Survey	9.9	7.4	4.4	4.9	2.3	0.5	34	82
National Science Foundation	**0**	**0**	**0**	**0**	**0**	**2.2**	**—**	**—**
Others	**397.2**	**487.6**	**552.8**	**583.0**	**492.7**	**508.1**	**−19**	**−5**
TOTAL	**$42,368.5**	**$35,607.1**	**$32,202.1**	**$27,246.1**	**$24,458.0**	**$23,410.4**	**19%**	**13%**
ANNUAL CHANGE	**19%**	**11%**	**18%**	**11%**	**4%**	**3%**		

Note: Fiscal years. a Estimated. b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, and others. **Source:** National Science Foundation

UNIVERSITY RESEARCH: Not much change in funding overall, but chemistry gets more

Federal obligations, $ millions	1987[a]	1986[a]	1985	1984	1983	1982	Annual change 1986–87	Annual change 1982–87
Life sciences	**$3124.8**	**$3288.8**	**$3192.2**	**$2800.2**	**$2460.0**	**$2205.0**	**−5%**	**7%**
Physical sciences	**816.9**	**757.2**	**749.7**	**697.8**	**596.5**	**559.1**	**8**	**8**
Chemistry	287.0	259.7	266.8	242.3	205.7	189.6	11	9
Physics	429.8	406.5	401.8	375.2	328.8	306.0	6	7
Engineering	**577.8**	**559.0**	**507.1**	**474.2**	**408.7**	**361.5**	**3**	**10**
Chemical	43.7	48.8	45.6	51.2	23.6	19.4	−10	18
Metallurgy and materials	121.1	125.9	107.2	87.7	86.0	75.3	−4	10
Environmental sciences	**410.2**	**380.2**	**361.1**	**319.5**	**316.9**	**274.7**	**8**	**8**
Mathematics and computer sciences	**338.3**	**302.8**	**253.1**	**181.6**	**172.4**	**139.7**	**12**	**19**
Other sciences	**360.6**	**367.4**	**347.8**	**304.1**	**297.8**	**255.7**	**−2**	**7**
TOTAL	**$5628.6**	**$5655.4**	**$5411.0**	**$4777.4**	**$4252.3**	**$3795.7**	**0%**	**8%**
ANNUAL CHANGE	**0%**	**5%**	**13%**	**12%**	**12%**	**2%**		

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

UNIVERSITY BASIC RESEARCH: More than half goes for life sciences

Federal obligations, $ millions	1987[a]	1986[a]	1985	1984	1983	1982	Annual change 1986–87	Annual change 1982–87
Life sciences	**$2267.5**	**$2379.2**	**$2306.8**	**$1979.6**	**$1701.7**	**$1483.7**	**−5%**	**9%**
Physical sciences	**714.1**	**646.7**	**628.8**	**581.9**	**502.2**	**455.3**	**10**	**9**
Chemistry	259.3	227.9	234.9	212.1	181.9	165.3	14	9
Physics	362.3	332.8	317.0	293.9	264.7	238.6	9	9
Engineering	**448.0**	**419.7**	**366.6**	**340.3**	**295.5**	**259.0**	**7**	**12**
Chemical	33.7	29.9	27.6	29.6	18.9	16.8	13	15
Metallurgy and materials	108.7	116.3	95.8	79.9	76.8	69.6	−7	9
Environmental sciences	**380.4**	**350.2**	**330.7**	**288.9**	**284.3**	**256.0**	**9**	**8**
Mathematics and computer sciences	**202.1**	**202.0**	**172.1**	**152.6**	**146.8**	**118.8**	**0**	**11**
Other sciences	**202.2**	**187.8**	**169.0**	**147.4**	**147.2**	**120.5**	**8**	**11**
TOTAL	**$4214.3**	**$4185.5**	**$3974.0**	**$3490.7**	**$3077.7**	**$2693.3**	**1%**	**9%**
ANNUAL CHANGE	**1%**	**5%**	**14%**	**13%**	**14%**	**9%**		

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

← CIRCLE 31 ON READER SERVICE CARD

BASIC RESEARCH IN PHYSICAL SCIENCE: NSF, Defense score biggest gains for chemistry

Federal obligations, $ millions	1987[a]		1986[a]		1985		1984		1983	
	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Energy	$ 852.5	$112.1	$ 743.1	$108.5	$ 736.1	$102.3	$ 688.4	$108.4	$ 639.2	$104.3
National Aeronautics & Space Administration	535.6	7.8	437.7	5.1	377.9	10.2	338.7	5.4	329.5	7.7
National Science Foundation	380.7	128.9	340.6	109.9	347.9	112.7	330.2	106.8	283.5	88.5
Defense	213.2	82.1	212.7	73.9	185.5	70.1	212.2	60.0	198.4	55.6
Navy	87.5	30.3	84.8	26.1	73.9	26.7	100.4	20.7	98.0	18.7
Air Force	77.6	32.7	63.9	27.0	54.1	22.8	48.3	20.3	39.3	17.5
Army	46.2	19.0	51.7	20.8	54.3	20.6	59.8	19.1	58.7	19.4
Defense agencies[b]	1.8	0	12.3	0	3.2	0	3.7	0	2.5	0
Health & Human Services	81.4	73.4	86.8	78.3	83.6	75.4	72.0	65.0	61.8	55.0
National Institutes of Health	79.3	71.4	84.6	76.1	81.5[a]	73.3[a]	70.8	63.8	60.9	54.2
Alcohol, Drug Abuse & Mental Health Administration	2.1	2.0	2.2	2.1	2.1	2.1	1.2	1.2	0.9	0.9
Agriculture	33.5	33.3	35.6	33.5	35.6	33.6	45.4	43.5	40.0	38.2
Agricultural Research Service	26.9	25.5	25.0	23.7	25.2	23.9	37.4	36.0	33.5	32.2
Cooperative State Research Service	4.6	4.6	6.1	6.1	6.4	6.4	5.4	5.4	4.1	4.1
Forest Service	3.9	3.2	4.6	3.7	4.0	3.3	2.6	2.1	2.4	1.9
Commerce	15.9	5.2	18.1	6.7	19.7	7.2	16.3	4.8	15.7	4.7
National Bureau of Standards	15.9	5.2	17.6	6.3	18.9	6.4	16.3	4.8	15.7	4.6
Interior	7.0	5.5	7.9	6.3	7.6	6.0	7.1	5.6	2.9	1.8
Geological Survey	7.0	5.5	7.9	6.3	7.6	6.0	7.1	5.6	2.6	1.8
Environmental Protection Agency	3.4	2.9	3.6	3.1	3.5	3.0	3.0	3.0	2.3	1.9
Others	17.8	0.4	15.6	0.2	16.6	0.3	14.7	0.9	13.5	3.5
TOTAL	$2141.0	$451.3	$1901.7	$425.4	$1814.0	$420.8	$1728.0	$403.4	$1587.2	$362.2
ANNUAL CHANGE	13%	6%	5%	1%	5%	4%	9%	11%	14%	16%

Note: Fiscal years. a Estimated. b Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, and others. **Source:** National Science Foundation

ENGINEERING RESEARCH: Support for chemical engineering drops sharply this year but is still twice

$ Millions	1987[a]			1986[a]			1985	
	Engineering	Chemical engineering	Metallurgy & materials	Engineering	Chemical engineering	Metallurgy & materials	Engineering	Chemical engineering
Defense	$1624.9	$ 54.5	$281.1	$1523.9	$ 50.3	$277.9	$1502.0	$ 53.3
Air Force	488.1	3.2	36.9	472.7	3.3	34.3	423.9	1.7
Army	434.9	23.5	41.3	336.1	20.9	37.7	344.3	26.7
Navy	409.9	27.8	120.1	408.5	26.1	121.1	421.2	24.8
Defense agencies[b]	292.1	0	82.8	306.6	0	84.8	312.6	0.1
National Aeronautics & Space Administration	1270.0	0.9	23.4	1021.6	0.8	17.7	931.6	0.6
Energy	322.0	58.8	73.6	463.6	126.2	68.7	511.3	136.6
National Science Foundation	231.3	41.2	47.6	195.6	34.4	42.1	193.3	32.6
Interior	69.6	4.4	25.4	94.9	4.9	40.9	100.2	4.8
Transportation	44.1	0.4	1.0	53.9	0.7	2.5	49.4	0.6
Environmental Protection Agency	43.7	17.5	2.5	45.6	18.1	2.7	44.8	18.0
Commerce	38.0	2.3	10.5	43.7	1.9	11.2	39.8	1.7
Agriculture	28.9	5.8	0	29.1	5.8	0	28.7	5.6
Others	185.3	0.3	0.5	212.5	0.4	0.4	227.4	0.4
TOTAL	$3857.8	$186.0	$465.5	$3684.4	$243.5	$464.1	$3628.5	$254.1
ANNUAL CHANGE	5%	−24%	0%	2%	−4%	6%	0%	76%

Note: Fiscal years. a Estimated. b Includes Defense Advanced Projects Agency, Defense Nuclear Agency, and others. **Source:** National Science Foundation

APPLIED RESEARCH IN PHYSICAL SCIENCE: Chemical funding down slightly this year

$ Millions[b]	1987[a]		1986[a]		1985		1984		1983	
	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Energy	$ 511.6	$ 24.9	$ 538.7	$ 37.3	$ 606.1	$ 40.6	$ 603.5	$ 32.0	$ 584.8	$ 13.3
Defense	434.8	102.7	415.1	93.4	412.0	86.3	477.2	79.8	562.0	66.3
Army	129.7	71.0	116.4	62.1	124.2	57.5	77.4	47.2	86.9	39.9
Air Force	59.0	17.0	60.2	17.3	57.5	16.7	58.6	16.4	54.5	13.7
Navy	55.6	13.9	53.9	13.4	50.7	11.6	69.2	15.9	135.2	12.3
Defense agencies[c]	190.5	0.8	184.6	0.6	179.6	0.4	272.1	0.3	285.4	0.3
National Aeronautics & Space Administration	81.9	6.0	79.9	6.0	76.3	6.1	25.6	1.9	40.4	1.7
Commerce	34.0	9.8	35.1	10.4	35.2	10.5	36.9	10.5	33.9	9.3
National Bureau of Standards	25.1	8.5	25.0	8.4	25.3	9.0	28.1	9.3	26.7	8.1
National Oceanic & Atmospheric Administration	8.9	1.3	10.1	2.0	9.9	1.4	8.9	1.3	7.2	1.2
Health & Human Services	26.5	23.0	28.4	24.6	27.3	23.6	24.7	21.3	22.6	19.2
National Institutes of Health	24.6	21.1	26.1	22.4	25.4[a]	21.8[a]	23.6	20.3	21.5	18.1
Alcohol, Drug Abuse & Mental Health Administration	1.9	1.9	2.3	2.2	1.9	1.9	1.1	1.1	1.2	1.1
Agriculture	24.2	22.2	25.8	23.8	26.4	24.4	27.3	25.5	27.6	25.6
Agricultural Research Service	13.9	12.9	12.9	12.0	13.1	12.2	16.9	15.6	18.6	17.2
Cooperative State Research Service	6.8	6.8	9.3	9.3	9.7	9.7	8.1	8.1	6.7	6.7
Forest Service	3.5	2.4	3.6	2.5	3.5	2.4	2.4	1.8	2.3	1.7
Environmental Protection Agency	15.4	14.1	16.1	14.9	15.7	14.5	13.8	12.9	13.9	12.8
Interior	14.5	12.5	16.2	13.9	15.5	13.3	15.7	13.6	5.5	4.4
Geological Survey	14.5	12.5	16.2	13.9	15.5	13.3	14.9	12.8	4.7	3.8
National Science Foundation	12.5	3.1	11.3	2.7	11.8	2.9	10.9	3.1	9.4	3.9
Others	3.9	1.3	3.3	1.0	3.8	1.4	5.4	2.4	4.2	1.6
TOTAL	$1159.3	$219.6	$1170.0	$228.0	$1230.1	$223.6	$1241.0	$203.0	$1304.3	$158.1
ANNUAL CHANGE	−1%	−4%	−5%	2%	−1%	10%	−5%	28%	1%	−7%

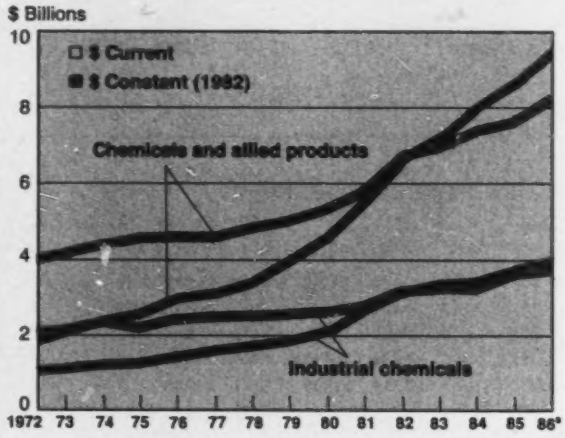
Note: Fiscal years. a Estimated. b Obligations. c Includes Defense Advanced Research Projects Agency, Defense Nuclear Agency, and others. **Source:** National Science Foundation

the level of five years ago

1985	1984			1983			1982		
Metallurgy & materials	Engineering	Chemical engineering	Metallurgy & materials	Engineering	Chemical engineering	Metallurgy & materials	Engineering	Chemical engineering	Metallurgy & materials
$260.9	$1488.4	$ 38.4	$180.3	$1573.9	$ 44.9	$179.3	$1473.3	$39.0	$159.3
28.6	439.5	3.5	30.3	419.3	3.1	38.2	387.3	2.9	35.1
42.2	324.8	23.5	35.5	318.9	29.3	28.4	297.2	24.4	31.7
121.1	398.4	11.3	53.9	395.5	11.9	50.0	378.0	11.6	49.3
69.0	325.7	0.2	60.6	440.2	0.6	62.8	410.8	0.2	43.1
15.8	**967.8**	**0.3**	**14.2**	**799.6**	**1.0**	**19.1**	**771.7**	**0.4**	**16.2**
68.4	**439.0**	**46.1**	**68.7**	**440.2**	**51.9**	**62.6**	**420.8**	**1.1**	**61.2**
42.7	**164.9**	**27.7**	**27.3**	**142.5**	**21.5**	**27.3**	**129.9**	**18.8**	**26.4**
39.8	**111.4**	**4.5**	**42.2**	**91.4**	**0.4**	**31.5**	**87.1**	**1.4**	**32.8**
1.5	**51.1**	**1.2**	**1.9**	**56.1**	**1.0**	**1.4**	**48.3**	**0.5**	**1.0**
2.6	**37.8**	**17.8**	**0**	**47.8**	**16.7**	**3.5**	**76.4**	**26.0**	**5.2**
6.9	**35.3**	**1.8**	**6.4**	**37.4**	**1.3**	**7.8**	**32.0**	**2.0**	**7.1**
0	**56.7**	**6.4**	**0**	**54.7**	**6.2**	**0**	**51.2**	**5.8**	**0**
0.5	**271.7**	**0.3**	**0.1**	**273.4**	**0.1**	**0**	**295.8**	**0.1**	**0**
$439.1	**$3624.1**	**$144.5**	**$341.1**	**$3517.0**	**$145.0**	**$332.5**	**$3386.5**	**$95.1**	**$309.1**
29%	**3%**	**0%**	**3%**	**4%**	**53%**	**8%**	**10%**	**36%**	**21%**

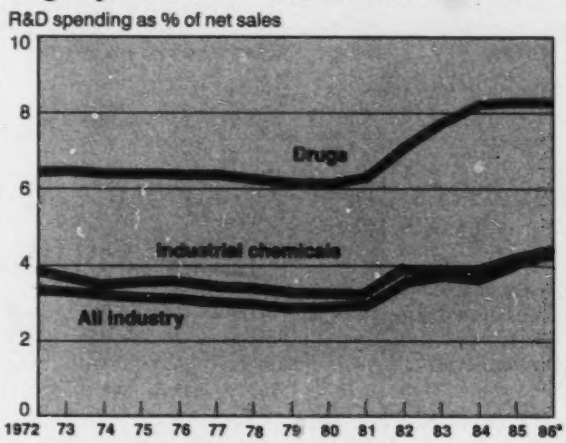
Industrial support for R&D up only 5%

With inflation low, chemical companies' R&D outlays rise smartly in real terms



a C&EN estimates. Source: National Science Foundation

Outlays for industrial R&D are rising at slightly faster rate than industrial sales



a C&EN estimates. Source: National Science Foundation

TOTAL FUNDS FOR INDUSTRIAL R&D: Drug producers continue to set a fast pace

$ Millions	1986a	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	Annual change 1985–86	Annual change 1976–86
Chemicals and allied products	$ 9,500	$ 8,667	$ 8,028	$ 7,293	$ 6,659	$ 5,625	$ 4,636	$ 4,038	$ 3,580	$ 3,202	$ 3,017	10%	12%
Industrial chemicals	4,150	3,915	3,512	3,411	3,301	2,802	2,197	1,962	1,798	1,668	1,524	6	11
Drugs	4,070	3,548	4,516	3,882	3,358	2,823	1,777	1,517	1,308	1,117	1,091	15	14
Other chemicals	1,280	1,204					662	559	474	417	401	6	12
Other industries	74,900	69,512	63,442	56,110	51,337	46,185	39,869	34,188	29,724	26,823	23,980	8	12
TOTAL	$84,400	$78,179	$71,470	$63,403	$57,996	$51,810	$44,505	$38,226	$33,304	$29,825	$26,997	8%	12%

a C&EN estimates. Source: National Science Foundation

COMPANY FUNDS FOR INDUSTRIAL R&D: Chemical industry spends about a sixth of the total

$ Millions	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change 1984–85	Annual change 1975–85
Chemicals and allied products	$ 8,352	$ 7,797	$ 6,845	$ 6,226	$ 5,205	$ 4,264	$ 3,692	$ 3,250	$ 2,907	$ 2,751	$ 2,490	7%	13%
Industrial chemicals	3,618	3,289	2,970	2,879	2,393	1,856	1,617	1,473	1,387	1,275	1,173	10	12
Drugs	3,545	3,381	2,937	2,490	2,064	1,756	2,075	1,777	1,520	1,476	1,317	5	14
Other chemicals	1,189	1,126	938	856	747	653						6	
Other industries	43,344	40,511	36,016	33,286	30,223	26,212	22,016	18,885	16,433	14,685	13,092	7	13
TOTAL	$51,696	$48,308	$42,861	$39,512	$35,428	$30,476	$25,708	$22,115	$19,340	$17,436	$15,582	7%	13%

Source: National Science Foundation

FEDERAL FUNDS FOR INDUSTRIAL R&D: Of little significance for the chemical industry

$ Millions	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change 1984–85	Annual change 1975–85
Chemicals and allied products	$ 316	$ 232	$ 448	$ 434	$ 421	$ 372	$ 346	$ 330	$ 295	$ 266	$ 236	36%	3%
Industrial chemicals	298	223	440	423	409	341	345	325	281	249	218	34	3
Drugs and other chemicals	18	9	8	11	12	31	1	5	14	17	18	100	0
Other industries	26,168	22,930	20,094	18,049	15,961	13,657	12,172	10,859	10,190	9295	8369	14	12
TOTAL	$26,484	$23,162	$20,542	$18,483	$16,382	$14,029	$12,518	$11,189	$10,485	$9561	$8605	14%	12%

Source: National Science Foundation

R&D BY U.S. COMPANIES ABROAD: Relatively small but expanding steadily

$ Millions	1986[a]	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	Annual change 1985–86	Annual change 1976–86
Chemicals and allied products	$ 900	$ 816	$ 793	$ 732	$ 684	$ 715	$ 603	$ 500	$ 395	$ 332	$ 312	10%	11%
Industrial and other chemicals	440	409	363	354	313	287	245	199	151	133	108	8	15
Drugs	460	406	430	378	371	428	357	301	244	199	204	13	8
Other industries	3100	2931	2786	2544	2413	2679	2562	2254	1814	1545	1347	6	9
TOTAL	$4000	$3747	$3579	$3276	$3097	$3393	$3165	$2754	$2209	$1877	$1659	7%	9%

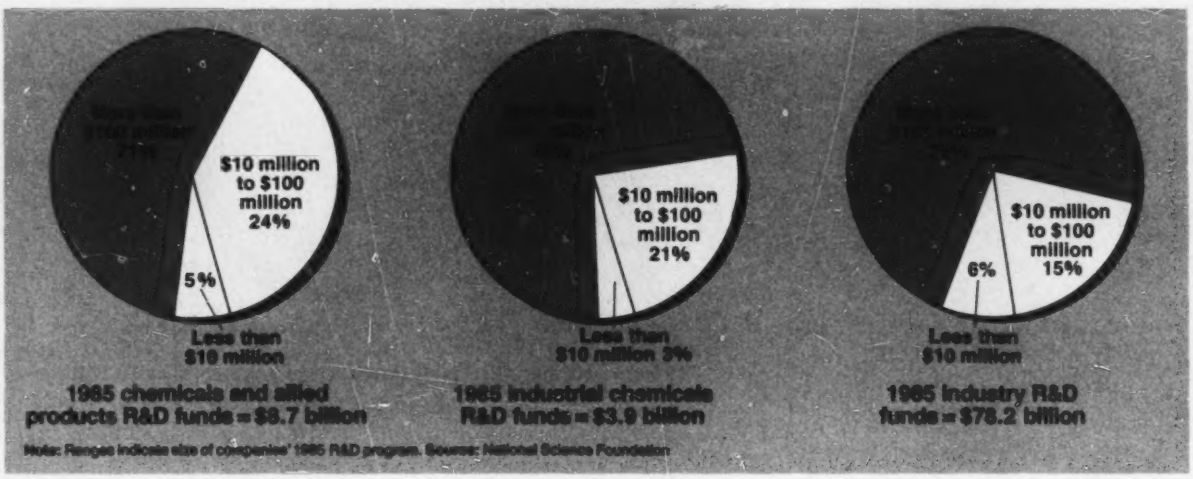
a C&EN estimates. Source: National Science Foundation

CHEMICAL R&D SPENDING: Slight rise last year largely reflects Carbide's major divestments

$ Millions	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1986 R&D spending as % of sales
Air Products	$ 61	$ 51	$ 44	$ 40	$ 37	$ 32	$ 30	$ 24	$ 23	$ 24	$ 19	3.1%
American Cyanamid	278	251	232	208	185	166	148	130	108	96	83	7.3
Dow Chemical	605	547	507	492	460	404	314	269	232	203	188	5.4
Du Pont[a]	1070	1080	1000	875	775	647	591	509	461	367	353	9.0
Ethyl	47	47	40	39	39	37	34	29	25	28	25	3.0
W. R. Grace	94	92	81	73	64	57	45	42	37	32	28	2.5
Hercules	71	76	72	74	74	65	57	50	43	40	37	2.7
International Flavors	39	34	32	32	31	30	29	27	24	20	16	6.3
Lubrizol	51	44	33	37	36	33	28	23	21	19	17	5.2
Monsanto	596	470	370	290	264	233	208	161	136	132	114	8.7
Nalco Chemical	33	32	32	30	33	30	28	21	17	14	12	4.5
Olin	56	53	52	49	45	36	31	26	25	25	23	3.3
Pennwalt	45	39	36	33	31	27	24	22	23	21	19	4.1
Petrolite	12	12	12	13	10	8	7	6	5	5	4	4.3
PPG Industries	204	176	150	127	127	119	103	83	70	61	56	4.3
Rohm & Haas	133	124	109	100	92	77	67	54	49	45	43	6.4
Union Carbide[b]	148	275	265	245	240	207	166	161	156	156	143	2.4
TOTAL	$3543	$3403	$3067	$2757	$2543	$2210	$1910	$1637	$1455	$1288	$1180	5.7%
ANNUAL CHANGE	4%	11%	11%	8%	15%	16%	17%	13%	13%	9%	8%	

a Figures exclude petroleum and coal segments. b Union Carbide divested a substantial part of its businesses in 1986; on a pro forma basis, R&D spending was $181 million in 1985 and $178 million in 1984. Source: Company data

Companies whose annual R&D budgets top $100 million do more than 70% of all R&D


$10 million to $100 million 24%
5%
Less than $10 million
1985 chemicals and allied products R&D funds = $8.7 billion
$10 million to $100 million 21%
Less than $10 million 3%
1985 industrial chemicals R&D funds = $3.9 billion
$10 million to $100 million 15%
6%
Less than $10 million
1985 industry R&D funds = $78.2 billion

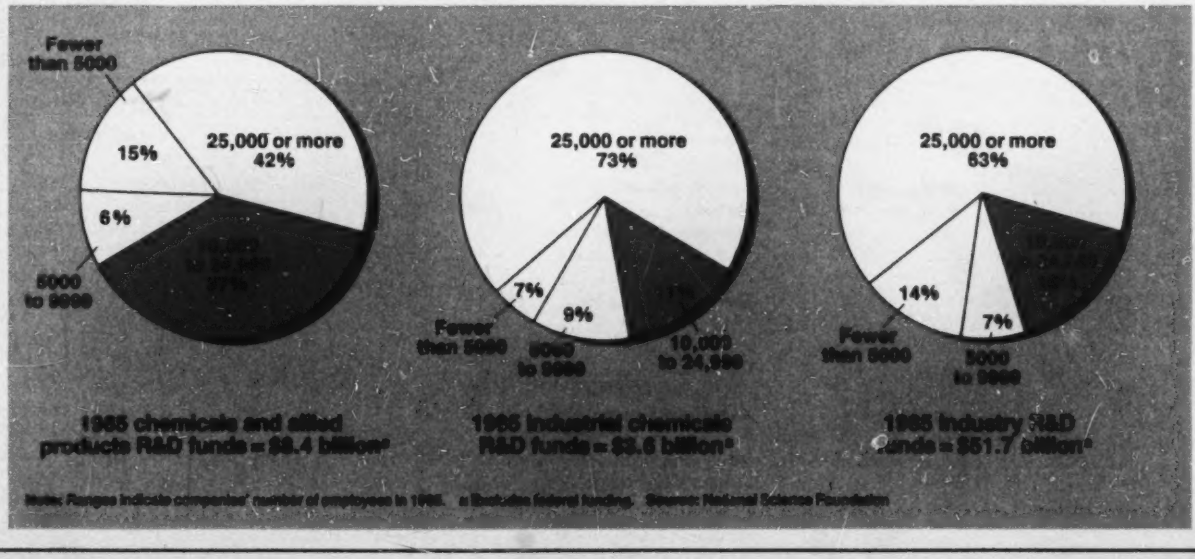
Note: Ranges indicate size of companies' 1985 R&D program. Source: National Science Foundation

R&D SCIENTISTS AND ENGINEERS IN INDUSTRY: Increasing faster for chemicals

Thousands[a]	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	Annual change 1985–86	Annual change 1976–86
Chemicals and allied products	**71.3**	**67.0**	**67.1**	**66.0**	**61.6**	**54.7**	**51.4**	**50.0**	**48.3**	**46.4**	**44.4**	**6%**	**5%**
Industrial chemicals	26.8	25.0	26.7	27.2	25.9	21.6	20.9	21.4	21.3	20.6	20.1	7	3
Drugs	33.3	30.7	30.1	28.2	25.6	23.3	21.6	20.8	19.5	17.8	16.6	8	7
Other chemicals	11.2	11.3	10.3	10.6	10.1	9.8	8.9	7.8	7.5	8.0	7.8	−1	4
Other industries	**509.0**	**493.2**	**477.4**	**456.1**	**448.2**	**433.1**	**399.2**	**373.9**	**356.1**	**336.4**	**320.0**	**3**	**5**
TOTAL	**580.3**	**560.2**	**544.5**	**522.1**	**509.8**	**487.8**	**450.6**	**423.9**	**404.4**	**382.8**	**364.4**	**4%**	**5%**

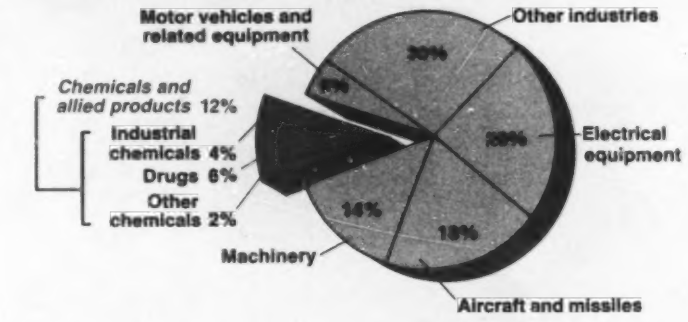
Note: Data as of January of each year. a Full-time equivalent. **Source:** National Science Foundation

Chemical companies with 10,000 to 25,000 employees perform more than a third of R&D



Notes: Ranges indicate companies' number of employees in 1985. a Includes federal funding. Source: National Science Foundation

Chemical and drug companies provide jobs for 12% of all industrial scientists and engineers



1986 total industrial R&D scientists and engineers[a] = 580,300

a Full-time equivalent, as of January 1986. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS PER 1000 EMPLOYEES: At new high in chemical industry

	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Chemicals and allied products	55	54	54	51	44	42	42	43	42	40	41
Industrial chemicals	42	44	45	44	37	36	36	38	38	36	38
Drugs	93	88	82	74	66	60	62	65	62	64	59
Other chemicals	38	37	36	36	33	30	27	27	29	28	29
All industry	36	38	35	33	29	27	27	27	27	27	26

Source: National Science Foundation

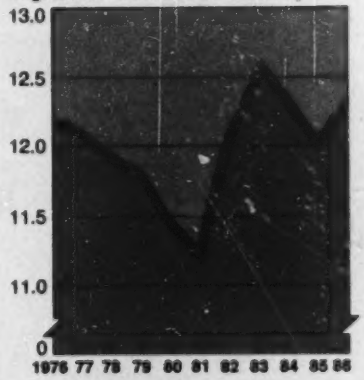
COST PER INDUSTRIAL R&D SCIENTIST OR ENGINEER: More than doubled in past decade

$ Thousands	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Chemicals and allied products	$125.2	$119.1	$109.6	$104.4	$ 96.6	$ 87.4	$79.6	$72.8	$67.6	$66.5	$60.9
Industrial chemicals	151.1	135.1	126.6	124.3	118.0	103.4	92.8	84.2	79.6	74.7	67.5
Drugs	a	111.2	100.7	a	a	79.2	71.4	64.8	59.9	63.4	60.9
Other chemicals	a	a	a	a	a	66.5	66.5	61.6	53.8	50.8	43.2
All industry	$137.0	$129.7	$118.9	$112.4	$103.9	$ 94.9	$87.4	$80.4	$75.8	$72.2	$66.5

a Not separately available but included in chemicals and allied products. **Source:** National Science Foundation

Chemical firms' share of R&D personnel up in 1986

% of total industrial R&D scientists and engineers in the chemical industry[a]



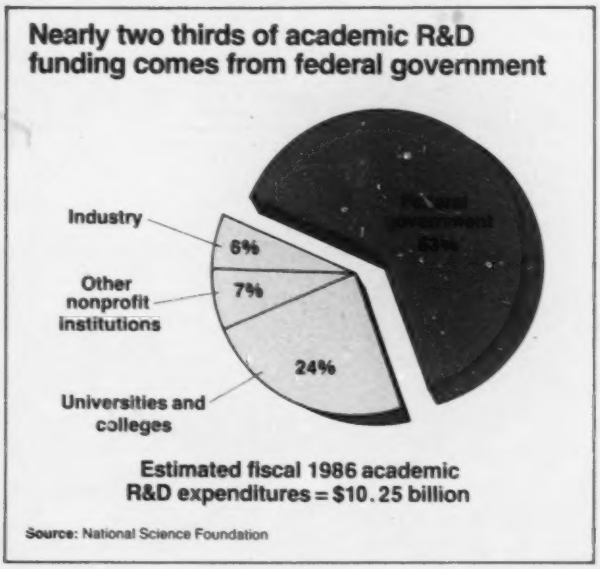
a Full-time equivalent, as of January of each year. **Source:** National Science Foundation

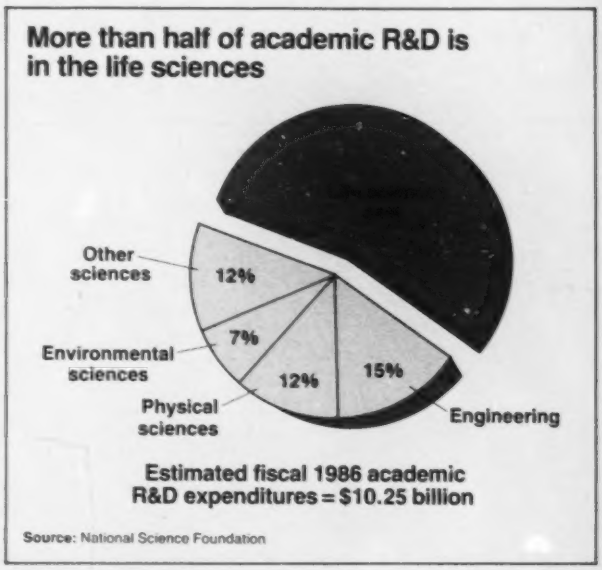
CHEMISTS IN INDUSTRY: Drugs biggest employer

Industry	% of industrial chemists				Mean salary ($ thousands)[a]		
	All chemists	B.S.	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Pharmaceuticals[b]	18%	17%	20%	17%	$40.3	$42.4	$57.2
Specialty chemicals	15	13	12	16	41.8	45.7	53.3
Basic chemicals	7	4	5	9	40.8	43.8	58.2
Plastics	5	5	6	6	42.3	47.6	56.6
Petroleum and natural gas	5	3	4	8	45.1	49.4	63.6
Agricultural chemicals	4	2	4	5	37.8	46.0	54.4
Coatings	4	5	4	3	41.6	47.7	50.6
Electronics	4	3	4	4	41.2	46.2	56.9
Food	3	5	4	2	39.8	46.2	56.5
Metals and minerals	2	4	2	1	40.2	38.8	47.0
Rubber	2	3	2	2	40.7	37.8	54.7
Biochemical products	2	1	2	2	35.1	35.5	57.5
Soaps and detergents	1	1	1	2	36.3	47.2	59.8
Paper	1	1	1	1	37.2	37.8	54.8
Other manufacturing	17	20	17	16	41.2	44.1	55.1
Nonmanufacturing	10	13	12	7	40.7	41.0	50.1

a As of March 1, 1987; to facilitate comparison, mean salaries are adjusted for differences in average length of experience for each group. b Includes personal care products. **Source:** ACS survey

University R&D increased 8% last year





CHARACTER OF UNIVERSITY R&D SPENDING: Basic research gets two thirds

$ Millions	1986[a]	1985	1984	1983	1982	1981	1980	1979	1978[b]	1977	1976	Annual change 1985–86	Annual change 1976–86
Basic research	$ 6,900	$6377	$5638	$5269	$4857	$4576	$4026	$3612	$3176	$2800	$2549	8%	10%
Applied research	2,760	2580[a]	2370[a]	2101	2004	1866	1691	1465	1213	1067	1015	7	11
Development	590	517[a]	495[a]	437	415	377	343	284	236	200	164	8	14
TOTAL	$10,250	$9504	$8503	$7807	$7276	$6819	$6060	$5361	$4625	$4067	$3729	8%	11%
ANNUAL CHANGE	8%	12%	9%	7%	7%	13%	13%	16%	14%	9%	9%		

Note: Data for institutional fiscal years. a C&EN estimates. b Estimated, based on data from Ph.D.-granting institutions only. **Source:** National Science Foundation

SOURCE OF UNIVERSITY R&D FUNDS: Federal share is largest, but it is falling

$ Millions	1986[a]	1985	1984	1983	1982	1981	1980	1979	1978[b]	1977	1976	Annual change 1985–86	Annual change 1976–86
Federal government	$ 6,400	$6003	$5388	$4960	$4752	$4562	$4096	$3595	$3059	$2726	$2512	7%	10%
Industry	580	538	458	379	334	291	237	194	170	139	123	8	17
Universities	2,500	2258	2024	1881	1690	1520	1319	1198	1037	888	810	11	12
Other sources	770	704	633	587	500	446	409	374	359	314	284	9	10
TOTAL	$10,250	$9504	$8503	$7807	$7276	$6819	$6060	$5361	$4625	$4067	$3729	8%	11%

Note: Data for institutional fiscal years. a C&EN estimates. b Estimated, based on data from Ph.D.-granting institutions only. **Source:** National Science Foundation

FIELDS OF UNIVERSITY R&D SPENDING: Biggest growth for computers and math

$ Millions	1986[a]	1985	1984	1983	1982	1981	1980	1979	1978[b]	1977	1976	Annual change 1985–86	Annual change 1976–86
All sciences	**$ 8,730**	**$8120.5**	**$7296.5**	**$6695.5**	**$6250.2**	**$5857.6**	**$5195.4**	**$4593.0**	**$4023.6**	**$3568.5**	**$3297.3**	**8%**	**10%**
Life	5,510	5138.5	4607.3	4233.0	3972.4	3673.1	3216.9	2832.5	2538.0	2258.8	2101.7	7	10
Physical	1,230	1136.6	996.9	898.9	824.3	766.3	677.4	601.9	469.4	423.5	379.4	8	12
Physics	600	549.9	470.8	414.4	366.2	357.2	322.2	292.0	235.1	201.7	183.1	9	13
Chemistry	435	414.5	371.2	336.0	309.4	285.1	244.0	206.4	183.1	159.4	140.1	5	12
Environmental	755	707.0	649.5	620.5	559.3	550.3	509.1	452.9	379.4	319.4	288.5	7	10
Computer	340	277.7	222.7	175.5	149.5	113.1	114.2	97.9	67.4	55.6	44.5	22	23
Mathematical	145	129.4	124.4	108.4	98.9	89.1	78.6	78.5	58.8	52.3	42.5	12	13
Others	750	731.3	635.7	659.1	645.8	645.8	599.1	539.3	483.7	458.9	440.7	3	5
Engineering	**1,520**	**1383.2**	**1206.4**	**1111.3**	**1025.8**	**961.0**	**864.9**	**768.4**	**601.1**	**498.5**	**431.7**	**10**	**13**
Chemical	115	109.0	96.2	90.8	83.6	83.2	67.6	na	na	na	na	6	na
TOTAL	**$10,250**	**$9503.7**	**$8503.0**	**$7806.8**	**$7276.1**	**$6818.6**	**$6060.3**	**$5361.4**	**$4624.7**	**$4067.0**	**$3729.0**	**8%**	**11%**
ANNUAL CHANGE	**8%**	**12%**	**9%**	**7%**	**7%**	**13%**	**13%**	**16%**	**14%**	**9%**	**9%**		

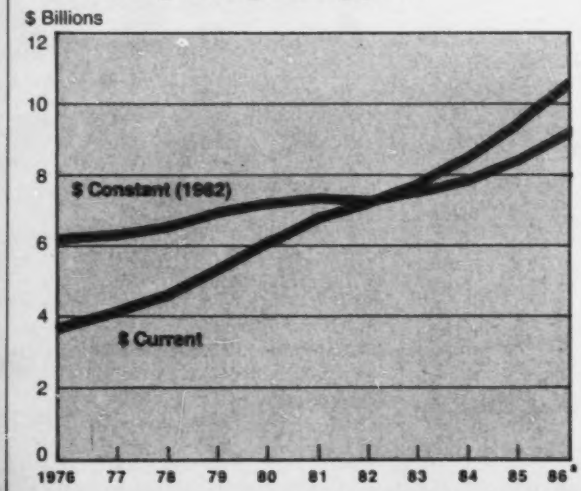
Note: Data for institutional fiscal years. a C&EN estimates. b NSF estimates, based on data from Ph.D.-granting institutions only. na = not available. **Source:** National Science Foundation

FEDERALLY FINANCED R&D SPENDING AT UNIVERSITIES: Growth slows in physical science

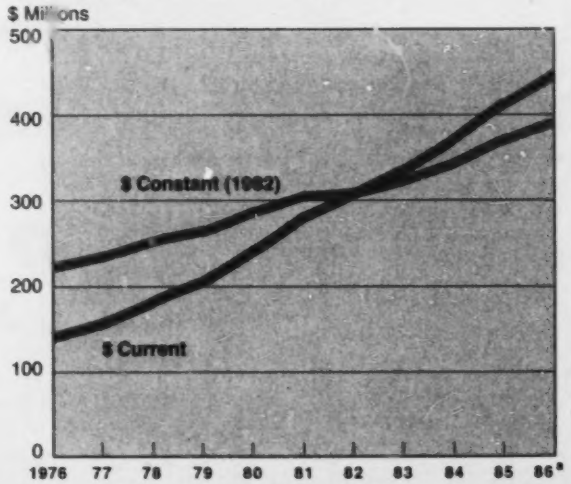
$ Millions	1986[a]	1985	1984	1983	1982	1981	1980	1979	1978[b]	1977	1976	Annual change 1985–86	Annual change 1976–86
All sciences	**$5420**	**$5145.0**	**$4609.4**	**$4221.8**	**$4054.0**	**$3899.3**	**$3500.6**	**$3068.9**	**$2651.2**	**$2389.4**	**$2221.3**	**5%**	**9%**
Life	3290	3138.7	2793.9	2565.3	2494.4	2364.2	2094.0	1818.8	1626.4	1474.0	1380.8	5	9
Physical	920	883.3	779.3	698.5	650.0	619.0	554.8	490.7	392.3	338.8	305.4	4	12
Physics	480	454.7	387.9	340.0	306.2	308.7	279.9	252.5	199.2	171.9	156.1	6	12
Chemistry	320	308.4	278.9	248.6	231.1	216.8	189.4	156.5	138.0	121.5	107.9	4	11
Environmental	500	480.7	451.5	427.9	392.2	392.7	372.5	329.2	275.1	238.6	211.8	4	9
Computer	230	193.1	161.6	127.8	107.0	93.5	77.0	69.2	41.2	37.5	32.9	19	21
Mathematical	115	96.1	91.3	76.7	72.1	67.9	61.1	60.4	44.1	40.6	32.9	20	13
Others	365	353.1	331.8	325.5	338.4	361.9	341.2	300.6	272.0	259.9	257.4	3	4
Engineering	**980**	**857.5**	**778.6**	**737.9**	**698.2**	**662.5**	**595.4**	**526.4**	**407.5**	**336.7**	**290.5**	**14**	**13**
Chemical	65	57.9	54.4	52.1	49.6	55.2	46.1	na	na	na	na	12	na
TOTAL	**$6401**	**$6002.6**	**$5388.0**	**$4959.7**	**$4752.2**	**$4561.8**	**$4096.0**	**$3595.3**	**$3058.7**	**$2726.1**	**$2511.9**	**7%**	**10%**
ANNUAL CHANGE	**7%**	**11%**	**9%**	**4%**	**4%**	**11%**	**14%**	**18%**	**12%**	**9%**	**10%**		

Note: Data for institutional fiscal years. a C&EN estimates. b NSF estimates, based on data from Ph.D.-granting institutions only. na = not available. **Source:** National Science Foundation.

Money for academic R&D, in constant dollars, is growing strongly . . .



. . . and funding for R&D in chemistry also forges higher in real terms



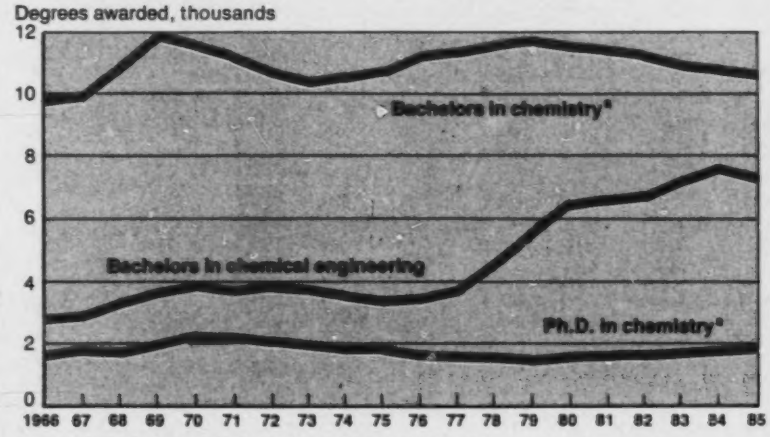
Note: Data for institutional fiscal years. a C&EN estimates. **Source:** National Science Foundation

TOP 10 UNIVERSITIES IN R&D SPENDING: 21% of total goes to top 10 institutions

$ Millions, fiscal 1985	Physical sciences	Chemistry[a]	Engineering	Environmental sciences	Life sciences	Math and computer sciences	Other sciences[b]	Total
1 Johns Hopkins U	$ 58.3	$ 4.2	$ 116.8	$ 28.3	$ 99.6	$ 71.7	$ 13.9	$ 388.6
2 Massachusetts Inst. of Technology	70.7	12.4	103.8	12.5	31.1	13.4	11.5	243.0
3 U of Wisconsin, Madison	23.7	5.2	21.8	17.8	115.8	7.4	21.9	208.4
4 Cornell U	36.2	6.3	30.6	5.2	114.5	6.6	10.1	203.2
5 Stanford U	35.2	7.1	58.3	3.2	83.1	14.1	5.3	199.2
6 U of Minnesota	11.2	3.3	18.1	3.7	127.2	3.4	9.7	173.3
7 U of Washington	11.6	2.0	11.9	18.0	99.8	3.8	18.9	164.0
8 U of Michigan	11.4	2.3	23.0	9.6	79.3	3.7	36.7	163.7
9 U of California, Berkeley	31.8	9.9	31.9	2.4	62.6	2.8	18.4	149.9
10 U of California, Los Angeles	15.5	6.7	18.5	8.8	93.3	1.2	12.4	149.7
TOTAL, TOP 10 INSTITUTIONS	$ 305.7	$ 59.4	$ 434.7	$109.4	$ 906.4	$128.1	$158.7	$2043.0
TOTAL, ALL INSTITUTIONS	$1136.6	$308.4	$1383.2	$707.0	$5138.5	$407.1	$731.3	$9503.7

a Included in physical sciences. b Includes social sciences, psychology, and other sciences not listed separately. **Source:** National Science Foundation

Fewer degrees awarded at undergraduate level



Note: Academic fiscal years. a Excludes biochemistry and geochemistry.
Source: National Center for Education Statistics

TOP 10 UNIVERSITY R&D CENTERS: 40% of funding goes to support work in physical sciences

$ Millions, fiscal 1985	Physical sciences	Engineering	Environmental sciences	Math and computer sciences	Total[a]
1 Lawrence Livermore Lab	$ 230.5	$ 432.2	$ 26.4	$ 95.0	$ 805.3
2 Los Alamos National Lab	335.8	233.0	16.9	64.1	704.0
3 Jet Propulsion Lab	72.7	295.2	61.8	236.5	666.2
4 Lincoln Lab	50.3[b]	186.2[b]	0	27.8[b]	264.5
5 Argonne National Lab	69.3	116.5	24.5	2.3	223.7
6 Brookhaven National Lab	134.7	29.5	9.4	0.7	199.0
7 Lawrence Berkeley Lab	103.6[b]	16.5[b]	17.6[b]	5.5[b]	174.6
8 Fermi National Accelerator Lab	151.3	0	0	0	151.3
9 Plasma Physics Lab	131.7	0	0	0	131.7
10 Stanford Linear Accelerator Center	79.7	0	0	0	79.7
All others	70.2	3.3	45.8	2.4	129.1
TOTAL, ALL FEDERALLY FUNDED R&D CENTERS	$1429.8	$1312.4	$202.4	$434.3	$3529.1

Note: Data for university-administered, federally funded R&D centers. a Includes life sciences and other sciences not listed separately. b Estimated. **Source:** National Science Foundation

CHEMICAL DEGREES: Doctorates increase

Academic fiscal year	Bachelors	Masters	Ph.D.s
DEGREES IN CHEMISTRY[a]			
1966	9,735	1839	1571
1967	9,872	1831	1744
1968	10,847	2014	1757
1969	11,807	2070	1941
1970	11,617	2146	2208
1971	11,183	2284	2160
1972	10,721	2259	1971
1973	10,226	2230	1882
1974	10,525	2138	1828
1975	10,649	2006	1824
1976	11,107	1796	1623
1977	11,322	1775	1571
1978	11,474	1892	1525
1979	11,643	1765	1518
1980	11,446	1733	1551
1981	11,347	1654	1622
1982	11,062	1751	1722
1983	10,746	1604	1746
1984	10,704	1667	1744
1985	10,482	1719	1789
DEGREES IN CHEMICAL ENGINEERING			
1966	2848	994	354
1967	2869	949	305
1968	3211	1156	367
1969	3557	1136	409
1970	3720	1045	438
1971	3615	1100	406
1972	3663	1154	394
1973	3636	1051	397
1974	3454	1045	400
1975	3142	990	346
1976	3203	1031	308
1977	3581	1086	291
1978	4615	1237	259
1979	5655	1149	304
1980	6383	1271	284
1981	6527	1267	300
1982	6740	1285	311
1983	7145	1304	319
1984	7475	1514	330
1985	7146	1544	418

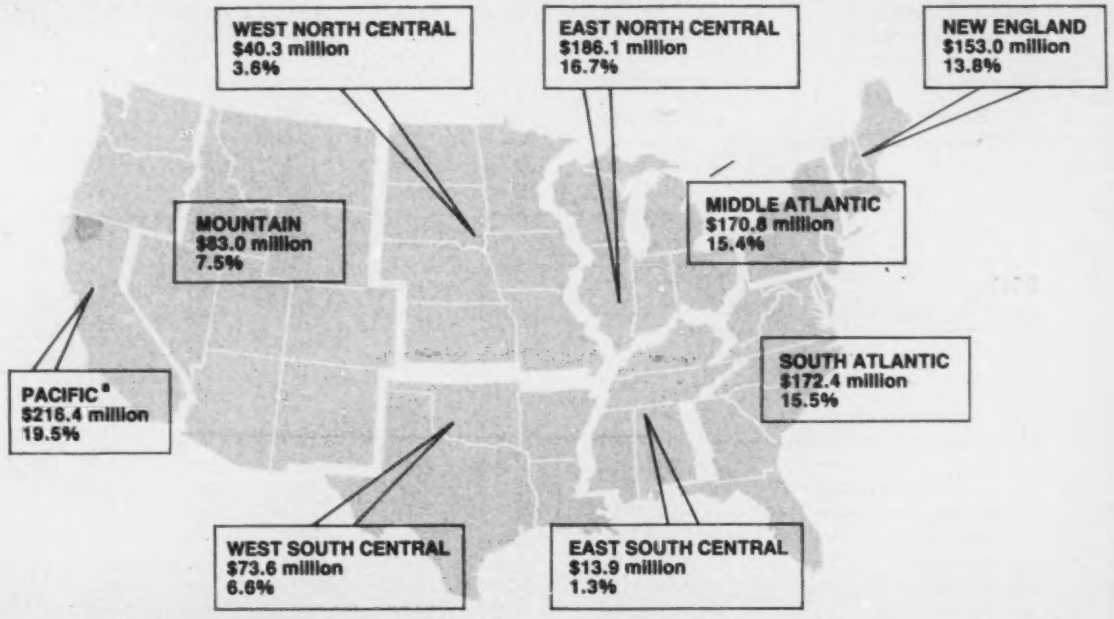
a Excludes biochemistry and geochemistry.
Source: National Center for Education Statistics

SCHOOLS SPENDING MOST ON CHEMICAL R&D: More than 20 spent at least $5 million in 1985

Rank 1985	Rank 1984		1985 Total spending ($ thousands)	1985 % federal funds	1984	1983	1982	1981	1980	Annual change 1984–85	Annual change 1980–85
							($ thousands)				
1	1	Massachusetts Inst. of Technology	$ 13,221	94%	$ 11,741	$ 8,914	$ 9,792	$ 8,222	$ 6,764	13%	14%
2	3	U of California, Berkeley	10,804	92	7,850	7,945	6,283	6,553	6,022	38	12
3	2	Harvard U	8,663	76	8,327[a]	6,898[a]	5,512[a]	6,123[a]	4,797[a]	4	13
4	5	Stanford U	8,354	85	6,809	6,375	6,116	5,564	4,788	23	12
5	6	Cornell U	7,962	79	6,710	5,717[a]	6,239[a]	4,615	3,808	19	16
6	8	California Inst. of Technology	7,605	92	6,446	6,994	6,136	6,901	6,328	18	4
7	12	U of Wisconsin, Madison	7,350	70	6,076	5,310	4,567	4,122	3,976	21	13
8	9	U of Maryland, College Park	7,289	46	6,324	6,333[a]	4,718[a]	3,109	2,766	15	21
9	4	U of California, Los Angeles	7,243	93	7,219	5,496	5,187	4,420	4,159	0	12
10	10	U of Illinois, Urbana	7,079	76	6,284	5,886	6,422	5,239	4,261	13	11
		Total, first 10 institutions	85,570	82%	73,786	65,868	60,972	54,871	47,669	16%	12%
11	16	Pennsylvania State U	6,509	90	5,124	4,729	3,564	3,413	2,973	27	17
12	26	U of Colorado	6,360	85	4,134	3,302	3,492	4,047	3,332	54	14
13	11	U of Massachusetts, Amherst	6,291	63	6,137	5,162	4,364	3,230	1,889	3	27
14	13	U of Chicago	6,287	91	5,735	4,798[a]	4,396	4,139[a]	3,958[a]	10	10
15	15	Purdue U	6,018	90	5,443	4,542	4,459	4,600	3,596	11	11
16	19	Texas A&M U	5,896	71	4,610	4,963	4,521	4,069	4,097	28	8
17	14	Indiana U	5,820	84	5,642	5,551	5,341	3,637	3,147	3	13
18	17	U of Notre Dame	5,549	92	4,760	4,022	4,020	3,855	3,457	17	10
19	27	Ohio State U	5,422	71	4,104	3,739	2,907	3,227	2,654	32	15
20	18	Columbia U, main division	5,188	87	4,662	4,281	4,700	3,564	4,437	11	3
		Total, first 20 institutions	144,910	82%	124,137	110,957	102,736	92,652	81,209	17%	12%
21	25	Yale U	5,096	90	4,134	3,341	2,875	2,781	2,023	23	20
22	20	Northwestern U	5,062	78	4,557	3,413	3,026	2,995	2,367	11	16
23	21	U of Pennsylvania	5,025	88	4,375	4,982	3,068	3,386	3,688	15	6
24	34	U of Utah	4,840	91	3,830	3,638	3,364	3,076	2,811	26	11
25	22	U of California, San Diego	4,642	87	4,355	3,910	3,894	4,430	4,425[a]	7	1
26	23	U of Oregon, main campus	4,640	85	4,255	3,351	2,971	1,389	1,119	9	33
27	7	U of Texas, Austin	4,588	47	6,639	5,938	4,843	4,779	3,970	−31	3
28	31	U of Pittsburgh	4,580	84	3,965	3,267	2,714	2,039	1,641	16	23
29	29	Johns Hopkins U	4,466	93	4,030	4,592[a]	4,721	4,066	4,652	11	−1
30	30	U of Florida	4,380	53	4,024	2,347	2,248	2,302	2,283[c]	9	14
		Total, first 30 institutions	192,229	81%	168,301	149,736	136,460	123,895	110,188	14%	12%
31	28	U of Minnesota	4,167	79	4,067	4,047	4,297	4,260	2,642	2	10
32	36	Princeton U	3,963	78	3,670	3,509	3,062	2,513	2,065	8	14
33	37	U of South Carolina	3,729	75	3,423	2,721	2,483	1,087[b]	970[a]	9	31
34	33	Georgia Inst. of Technology	3,684	56	3,846	3,401	3,327	3,660	3,655	−4	0
35	40	State U of New York, Stony Brook	3,481	67	3,084	2,607	2,783	2,691	1,966	13	12
36	38	Lehigh U	3,456	39	3,361	3,664	2,584	1,680	1,066	3	27
37	24	U of Connecticut	3,429	44	4,135	2,720	2,049	1,748	1,300	−17	21
38	44	Virginia Polytechnic Inst. & State U	3,339	59	2,633	2,206	1,740	1,581	1,612	27	16
39	39	Florida State U	3,276	32	3,137	2,500	2,959	3,012	2,791	4	3
40	—	Howard U	3,269	91	3,672	2,336	982	1,406	1,287	−11	20
		Total, first 40 institutions	228,022	79%	203,329	179,447	162,726	147,533	129,542	12%	12%
41	44	Michigan State U	3,222	60	2,869[b]	2,714	2,493	2,178	1,638	12	14
42	41	U of North Carolina, Chapel Hill	3,201	90	2,945	2,397	2,240	2,016	1,789	9	12
43	32	U of Rochester	3,196	90	3,858	3,167	3,123	2,966	2,089	−17	9
44	—	U of California, Irvine	3,142	97	2,177	1,777	1,661	1,915	1,398	44	18
45	—	U of California, Santa Barbara	3,060	89	2,172	1,902	1,698	1,834	1,434	41	16
46	—	U of Virginia	3,046	71	2,516	2,069	1,778	1,781	1,203	21	20
47	—	Iowa State U	2,988	41	2,239	1,903	1,462	1,272	1,159	33	21
48	—	U of Washington	2,964	68	2,340	2,162	2,276	1,500	1,326	27	17
49	40	Wayne State U	2,093	99	3,071	2,645	2,656	2,261	2,163	−32	−1
50	—	Syracuse U	2,900	52	2,110	2,171	2,868	2,259	764	37	31
		Total, first 50 institutions	$258,644	78%	$229,626	$202,354	$184,981	$167,515	$144,505	13%	12%
		NATIONAL TOTAL	$414,529	74%	$371,182	$336,025	$309,371	$285,520	$244,454	12%	11%

Note: Data for institutional fiscal years. a Estimated. b Imputed. **Source:** National Science Foundation

East and West Coast schools account for 64% of R&D spending in physical sciences



Key to map: Using the Middle Atlantic states as an example, $170.8 million, or 15.4%, of all R&D expenditures in the physical sciences by all Ph.D.-granting universities and colleges are made in this geographical area. **Note:** Data are based on R&D expenditures of $1.11 billion in the physical sciences during the 1985 fiscal year.
a Includes Alaska, Hawaii, and outlying areas. **Source:** National Science Foundation

GRADUATE SCIENCE STUDENTS: Chemistry, biochemistry, chemical engineering total 8%

Thousands	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	Annual change 1984–85	Annual change 1975–85
Physical sciences	**29.4**	**28.4**	**27.7**	**26.5**	**25.8**	**25.4**	**24.9**	**24.7**	**24.8**	**24.8**	**24.5**	**4%**	**2%**
Chemistry	17.3	16.6	16.5	15.8	15.2	15.1	14.9	14.8	14.6	14.4	14.1	4	2
Physics	11.3	11.0	10.5	10.0	9.9	9.6	9.3	9.2	9.5	9.6	9.6	3	2
Life sciences	**93.8**	**92.5**	**91.2**	**90.7**	**90.9**	**90.7**	**87.5**	**85.9**	**83.3**	**77.2**	**73.6**	**1**	**2**
Biochemistry	4.7	4.5	4.2	4.1	4.0	4.0	3.9	4.0	3.8	3.7	3.7	4	2
Engineering	**91.8**	**88.3**	**86.4**	**78.2**	**74.4**	**70.1**	**67.2**	**64.3**	**64.4**	**62.9**	**64.6**	**4**	**4**
Chemical	7.0	7.2	7.4	6.9	6.3	5.9	5.4	5.2	5.1	5.1	4.9	−3	4
Metallurgical & materials	3.8	3.6	3.3	3.0	3.0	2.8	2.7	2.5	2.5	2.3	2.3	6	5
Petroleum	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.3	14	10
Environmental sciences	**14.3**	**14.3**	**14.3**	**13.8**	**13.1**	**12.8**	**12.6**	**12.2**	**12.3**	**11.7**	**11.0**	**0**	**3**
Mathematical and computer sciences	**39.0**	**35.4**	**33.2**	**30.3**	**27.1**	**25.0**	**22.7**	**21.5**	**21.1**	**21.7**	**21.3**	**7**	**6**
Psychology and social sciences	**102.8**	**104.5**	**105.4**	**107.3**	**108.7**	**109.7**	**105.8**	**101.2**	**100.6**	**99.8**	**98.7**	**−2**	**0**
TOTAL	**371.1**	**363.5**	**358.1**	**346.8**	**340.0**	**333.7**	**320.6**	**309.8**	**306.6**	**298.2**	**293.8**	**2%**	**2%**
ANNUAL CHANGE	**2%**	**2%**	**3%**	**2%**	**2%**	**4%**	**3%**	**1%**	**3%**	**1%**	**—**		

NOTE: Data for Ph.D.-granting institutions only. **Source:** National Science Foundation